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EFFECTS OF FEDERAL FUNDS STUDIED

Harvard University is undertaking the study of the effect of Federal funds upon its schools, laboratories, departments and teaching programs. Federal programs have been having an increasing impact on all universities throughout the country in the years since World War II. Federal financial support has become an important element in many of the research programs in providing research for graduate students and in the construction of physical facilities. The money Harvard receives from government contracts and grants now amounts to nearly 20 per cent of its budget, and Harvard wishes to discover what effects these new funds have on her traditional educational and research programs. Dr. D. S. Cheever, Lecturer in Government, is in charge of the study.

Do You Know

► That the Annual Meeting at Purdue was the biggest and the best? Purdue's facilities were incomparable, the planning by the local committee was thorough and well carried out, and the programs were terrific! The weatherman also cooperated. There were 1,534 paid attendees, 571 women and children, and a total out of town attendance of 2,189. All who participated in the programs and those who planned them are to be commended. Let their performance be a challenge for this year's committees.

► That a portion of last year's highly successful programming undoubtedly was due to effective early planning? Much had been accomplished by October. So, if your Division or committee hasn't done anything yet it is time to start. The theme for the Annual Meeting is "Engineering in International Relations." Also, the International Relations Committee, now a committee of ASEE instead of ECAC, is sponsoring a general session on Tuesday morning. The theme should be considered in making your plans.

► That you can find out about what you missed at the Annual Meeting at Purdue? Read "Quality and Quantity" on page 14 and "What's Going On In ASEE" on page 18. Reports and papers will be published throughout the year in the JOURNAL.

► That a bang-up finish brought the new member total for last year to 972, just a little above the average for the previous three years? Now we start all over again. A membership application is on page 80. Tear it out and give it to a co-worker. Many people say they haven't joined because they haven't been asked. This year an organized effort will be made through the Sections with a representative at each school. Last year's inquiries revealed that only about 50% of the full-time members of engineering faculties belong to ASEE. So the potential is there—get your man! The goal for the year again must be 1000! Membership brochures and application forms also can be obtained from your dean.

► That the next Annual Meeting will be at the University of Kentucky at Lexington on June 26–30? The only hoss race now predicted is who will get there first. H. A. Foecke got a special badge for being the first to preregister at Purdue. Kentucky probably will have to recognize win, place, and show.

► That all 50 states, six foreign countries and Puerto Rico were represented at the Annual Meeting at Purdue?

► That "Teaching Positions Wanted" is to be a new classified ad section of the JOURNAL? The Executive Board approved its establishment in order to afford non-members of ASEE wishing to go into teaching an opportunity to advertise. The cost will be $2.00 per line, the same as for the "Teaching Positions Available" section. The new section also is open to members of ASEE engaged in teaching if they want to use it.

► That before long you will be asked to submit suggestions for officers for 1961–62 for the consideration of the Nominating Committee? In considering suggestions remember that the presidency is a working job and that the Society's basis of operation places leadership responsibilities on him; further, to do an effective job he must be familiar with ASEE. That is why it is traditional or customary, if not almost mandatory, that the president be selected from among past vice presidents. To be a vice president it is not necessary to be a dean! The Treasurer, though elected annually, is expected to serve a minimum of three years; further, by custom he is from industry and he pays his own expenses to all meetings.

► That Deans J. M. Pettit of Stanford, F. H. Pumphrey of Auburn and F. M. Tiller of Houston are the new members of the Executive Committee of ECAC? Dr. H. E. Wessman and Dean W. P. Kimball continue to serve as Chairman and Secretary, respectively.

► That R. J. Martin, Director of the Engineering Experiment Station, University of Illinois, is the new chairman of ECRC and vice president of ASEE? ECRC Vice Chairman for one year is C. C. Chambers of the University of Pennsylvania and Vice Chairman for two years is J. C. Calhoun, Jr. of the A. & M. College of Texas. Newly elected directors are M. A. Williamson of Penn State, R. E. Burroughs of the University of Michigan, and J. W. Hoffman of Michigan State. W. E. Miller, Associate Head of the E. E. Department at the University of Illinois, is the new secretary.

► That "A Selected List of Career Guidance Publications" is published by the American Association for the Advancement of Science? About 130 publications are listed under various headings. Twenty-seven are listed under engineering but some under other headings also include some reference to engineering. Copies may be obtained without charge from AAAS at 1515 Massachusetts Avenue, N.W., Washington 5, D. C.

► That a cooperative plan for guidance and admission of secondary school students to college has been developed by the Educational Testing Service? New electronic data processing techniques are used to marshall the entire cumulative record of each student for guidance, college admission, and employment. A graphic summary and interpretation is provided of the student's total high school performance—marks, test scores, honors, activities, health record, personal characteristics, whatever the schools and college agree on—in a form that is comparable for all schools, is easily interpreted and used, and is less expensive than current record and transcript systems. Georgia is the first state to adapt the plan to its needs.

► That *Werkstatt und Betrieb* is a German Journal with English translations, available since January of 1960? A twelve-month subscription costs about $17 and the area covered is machine tools and production. Subscriptions should be sent to Carl Hanser, Zeitschriftenverlag Gmbh., Munich 27, Western Germany.

► That *Statistical Handbook of Science Education* (NSF-60-13) is a compilation of statistical material on the education and training of scientists and engineers in the United States? It should be a useful reference work for anyone interested in science and engineering education in the United States. Much of the information is presented in graph form, with accompanying tabular material to aid those needing more exact statistics. Copies can be obtained for 55¢ each from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Engineering libraries and deans' offices probably will be interested.

► That a "Division of Materials Sciences" has been established by the American Society for Testing Materials? This is a much needed aspect of ASTM's activities and the Division got off to a good start in sponsoring a special program at ASTM's last Annual Meeting. The two symposia are entitled "Recent Progress in Materials Sciences" and "Nature and Origin of Strength of Materials." All inquiries in regard to the papers presented should be directed to ASTM, 1918 Race Street, Philadelphia 1, Pa.

► That the House Education and Labor Committee has been urged by NSPE to amend the Fair Labor Standards Act to accord to registered professional engineers the same status presently granted licensed doctors and lawyers except from the minimum salary requirement for professional employees? Under current regulations for employees

in a bona fide professional capacity there is a requirement that employees must earn at least $95 per week to qualify as professionals, but it does not apply to licensed doctors or lawyers who are actually engaged in the practice of their profession. The basis of the action is that since state legislatures and the Congress of the United States have declared the professional status of licensed engineers, there is no justification to ignore that fact in providing special exception from the salary test for licensed and certified professionals.

► That the Engineering Manpower Commission of Engineers Joint Council voted, "The Commission, through its staff, take all reasonable measures to appraise college deans of the advisability of students taking the Selective Service Qualification Test." Since the present average age of induction is 22½ years, the test is especially important if there is a possibility of the student entering graduate school. College graduates may otherwise qualify for deferment as graduate students if they stand in the upper part of the male graduates of the senior class. The student may have a greater chance of success if he takes the test in his sophomore or junior year rather than as a freshman.

► That the Engineering Manpower Commission of EJC continues to support the Junior Engineering Technical Society, JETS, and voted to endorse the JETS application to the National Science Foundation for continued support? The Commission also voted that, "It is unable to endorse the Future Engineers of America at this time." The reasons for not endorsing the organization are that its publicity seemed to lack the degree of dignity one would expect of a group dedicated to preparing high school students for a profession, the exclusive emphasis on mathematics, and uncertainty regarding the organizational structure. Additional information is being sought.

► That data for the next edition of *Who's Who In Engineering*, to be published early in 1962, will be requested in the near future? In order for the book to best serve its purpose, those receiving requests for data and who are eligible for listing should return the forms promptly. The Lewis Historical Publishing Company reports that the 8th edition, 1959, was so well received that on the recommendation of EJC's Who's Who Committee it will be published every three years in the future.

► That in the *Technical Education News* for May 1960 the editor, Miss Jeanne Miller, made some interesting comments in her editorial? The formation in 1941 of the Technical Institute Division of ASEE (then SPEE) led McGraw-Hill to undertake the publication of *T.E.N.* "We have watched the struggle for recognition and understanding and have been pleased to chronicle each step of progress made. Among these steps we would list the following:

"The leadership of the ASEE's Technical Institute Division is taking the story of technical institutes to engineering education and to industry.

"The increasing emphasis on quality and upgrading and the drive toward accreditation.

"The formation and missionary work of organizations such as the National Council of Technical Schools and the American Technical Education Association.

"The work of the Task Force on Technical Supporting Personnel in bringing the importance of the technician to the attention of the President's Committee on Scientists and Engineers, and through this Committee to the public.

"The recognition and support given to the movement by the U. S. Office of Education, particularly the service provided in the annual gathering and publication of statistics on enrollments and graduates in *Organized Occupational Curriculums.*

"The National Survey of Technical Institute Education, and the followup Technical Institute Evaluation Study now in progress, both conducted by the American Society for Engineering Education."

W. Leighton Collins
Secretary

Dr. Eric A. Walker

Eric A. Walker

ASEE President 1960-61

There is an old adage that if you want a job done, give it to the busiest man you can find. If there is any truth to this adage, this coming year should be an extremely productive one for ASEE. President-elect Eric Walker must surely be one of the busiest men in the United States.

Born in England in 1910, Eric Walker was graduated from the Wrightsville, Pennsylvania, high school and holds three degrees from Harvard: B.S. in Electrical Engineering (1932), M.S. in Business Administration (1933), and Sc.D. in Engineering (1935). In addition, he has been awarded honorary degrees by seven colleges and universities, including one from a medical college!

After teaching electrical engineering at Tufts College and the University of Connecticut, he moved back to Harvard in 1942 as Associate Director of the Underwater Sound Laboratory, the organization that developed the homing torpedo that broke the back of the German U-boat menace.

After the War, he became Director of the Ordnance Research Laboratory, which had been established at The Pennsylvania State University to continue the war-time work that had been started at HUSL. At the same time, he served as Head of the Department of Electrical Engineering at Penn State. In 1951, he was appointed Dean of the College of Engineering and Architecture, was named Vice President in 1956, but was selected to succeed Dr. Milton Eisenhower as President even before he had a chance to move into his new office.

During this time, he was called upon repeatedly to serve his adopted country as an administrator, a scientist, and an engineer. In 1950–51, he served as Executive Secretary of the Research and Development Board, was Vice Chairman of the President's Committee for Scientists and Engineers between 1956 and 1958, and served as Chairman of the President's Conference on Technical and Distribution Research for the Benefit of Small Business in 1957. He is a member and former Chairman of the National Research Council's Committee on Undersea Warfare, is now a member of the Naval Research Advisory Committee, and served as a member of the Army's Scientific Advisory Panel in 1956–58. He served as Chairman of the National Science Foundation's Committee for Engineering between 1951 and 1953 and was appointed just this fall as a member of the National Science Board of the Foundation.

He has served—and continues to serve—education broadly as an advisor and counselor. He is a member of the Board of Visitors of the U. S. Naval Academy, serves on the Executive Committee of the American Association of Land-Grant Colleges and State Universities and is this year President of the Pennsylvania Association of Colleges and Universities. In addition, he is a member of the Commission on Higher Education of the Middle States Association of Colleges and Secondary Schools.

He has served on numerous ASEE committees and was, in 1952–54, Vice President of the Society and Chairman of ECRC. He is a fellow of AIEE, the American Physical Society, the American Acoustical Society, and IRE. He is a member of the American Institute of Physics, Sigma Xi, and Tau Beta Pi. He has been elected as a member of the Board of Directors of the Westinghouse Air Brake Company, is a trustee of the Institute for Defense Analysis, and has twice served as member of the State College, Pennsylvania, Borough Council. He was awarded a Presidential Certificate of Merit in 1948 for his work in connection with the development of the

(*Continued on page 17*)

Wanted: Leadership in Engineering Education

Presidential Address—Annual Meeting
Purdue, June 1960

B. RICHARD TEARE, JR.

Dean, College of Engineering and Science, Carnegie Institute of Technology and President, American Society for Engineering Education, 1959–1960

The close of the Society year is an appropriate occasion for stocktaking; it is an opportune time to look at the road over which we have come and then to consider where we now stand and where we are headed. It is a time to re-examine the functions of the Society to see what activities need strengthening, what problems are urgently in need of solution, and what new activities should be initiated.

In its sixty eight years of existence the American Society for Engineering Education has supported and served the evolutionary development of an education which has had, at least indirectly, a profound influence upon the lives of everyone. Engineering education has produced the graduates who have been responsible for today's technology, that technology which is a distinguishing characteristic of the present age. In fact, all industrial activity depends heavily upon engineering, which is the product of our product; to a growing extent so do matters of government policy. Thus, the profession of education for engineering is of consequence far beyond what is indicated by our membership of less than 10,000. We well may be proud of our place in the scheme of things but perhaps somewhat awed by our responsibilities.

What have we accomplished in our nearly three score and ten years of life? The important thing has been a significant contribution to the coordination, direction and quality of engineering education. This is done in part by annual meetings like this one, and by section and branch meetings, all of which serve as forums. I am reminded of what Dean Barzun says of intellectuals: "We like ideas, new ideas especially, and we drive a brisk trade in them. The quickest way to get three Americans to travel a thousand miles is to propose an exchange of ideas."

We have not only our forums, but also our JOURNAL OF ENGINEERING EDUCATION, which serves to record the best of our ideas.

It is interesting to look at the early papers. Mostly they show their age, but now and then there is one that is applicable today; for example, the very first paper of Volume 1 of the Proceedings. The author, Professor William H. Barr, pointed out that a fundamental characteristic of the ideal education for engineering is

". . . a thorough training in what may be termed the natural philosophy of engineering, which embraces all that body of mathematical scientific knowledge constituting the pure theory of engineering operations. This lies directly at the foundation of the professional engineer's practice. Indeed, this feature of an engineer's educational training is as profoundly practical as it is profoundly theoretical. . . . Now, whatever duty an engineer may be called upon to perform in a professional way, whether to design an engine or an electric plant, or to build a bridge, a system of water works, or a railroad, he is inevitably compelled to pursue either the one or the other of two courses. He may blindly follow precedents, and do something simply because somebody has done something else more or less like it, adopting the handbook method of construc-

tion and thus get a result which may for a time satisfy his clients and enable him to secure his compensation, but which he is utterly unable to defend from criticism and which sooner or later the better equipped engineer must usually be required to remodel or reconstruct, either in whole or in part. Or, on the other hand, he may approach his work with an intelligent appreciation of the principles or laws which govern the physical sequence of the things that he is to control and adapt to the use and convenience of that part of mankind served by his clients or directly by himself. In one case he imitates and in the other he creates. In the former he is defenseless against his own ignorance, while in the latter he is equipped for perfect safety, even though he may occasionally err. I do not underrate the value of experience in completing the education of the engineer; experience is an imperative necessity for every human being, and the engineer forms no exception to the law. In fact, his complete education consists of two parts. The first is that systematic and logical training in so much of the mathematical and physical sciences as is included directly in engineering operations or as may be indirectly required by them, and which collectively constitutes the natural philosophy of engineering, which training is secured only in the professional school; while the second results from the experience of the first few years of the young engineer's practical life, and it consists in attaining a capacity to submit the acquisitions of the first to the operation of common sense and a well-trained judgment, and thus make them applicable to the real conditions of professional practice."

Professor Barr's words of 1893 are germaine today, and they remind us that we still have the problem of giving adequate emphasis to mathematics, science, and engineering fundamentals. In fact as technology has made its great advances over the years, the temptation to teach the newest art and practice of engineering has always been considerable and has had to be constantly resisted. It is to the credit of engineering education that this recurring problem has been met and solved each time it has arisen.

Projects and Results

Although our forums and our proceedings have been valuable, I think that we have made an even more effective contribution through the projects carried on by groups of our members who have debated important issues in small meetings until definite conclusions were reached. These projects include the comprehensive studies of 1918 by C. R. Mann, and of 1929 by W. E. Wickenden, the *Aims and Scope of Engineering Curricula*–1940, *Engineering Education After the War*–1944, *Manual of Graduate Study*–1945, revised in 1952, *Improvement of Engineering Teaching*–1952, *Evaluation of Engineering Education*–1955, *Humanistic-Social Research Project*–1956, *Facilities and Opportunities for Graduate Study in Engineering*–1958, and the important *Engineering Faculty Recruitment, Development and Utilization* of this year. And there have been others.

Such studies have been significant in the development of engineering education because they have dealt in an organized manner with important questions, and they have led to carefully considered recommendations. They may have suffered because opinions of committees are more conservative than those of individuals, but they have extra validity because they have survived the battle of spirited discussion and criticism by experts. Sometimes, as in the Evaluation Study, controversial matters were referred to all of the educational institutions for comment and such comments had a considerable influence on the final recommendations. These reports have had an important effect on education, but this has been more often indirect than direct since procedures and even standards in our field are established by each individual institution for itself, except for the influence of accreditation. In our system the most rapid progress has been made when recommendations of the project reports were incorporated into accrediting standards.

In retrospect the studies that have been mentioned do not seem to be very radical or daring; in fact, one wonders if they went far enough. Had they been more far-reaching, as the Flexner report was for medicine, we might be further ahead today.

Moreover, it is becoming apparent that studies of the kind that we have made in the past are not sufficiently

penetrating for many of the critical problems that we face today. The earlier studies were based for the most part upon the opinions and convictions of the people who participated, informed opinions it is true, and perhaps the best in our profession; and little else was readily available. But now it is high time that we bring genuine research techniques to bear on problems in education just as we would on problems in engineering and make use of the most powerful methods of psychology, education, and other relevant disciplines.

Problems Ahead

These are the techniques we must employ; now let us consider some of the problems that we as a society should deal with if we are to furnish today's and tomorrow's leadership in engineering education.

Two of the oldest problems, those of quantity and quality, have a new urgency which results from the rapid advances in technology of the last decade or two. The quantity problem is deceptive because for many years it was not very serious and in fact will not reach its greatest severity until some time in the future when it may be too late for quick remedies. Until about twenty years ago we turned out more engineers than were needed for genuinely professional levels of practice; industrial employers sorted them out and placed a good many in sub-professional work without always recognizing that this was happening. A small fraction of the most able graduates developed their capacities to a high level of professional leadership with the help of post-graduate study or company courses, or even wholly on their own, and their number had to be supplemented by importation of the products of European schools. However, the situation in general was one of fair balance between supply and demand up to the time of World War II, except of course for the temporary dislocations caused by cycles of "bust and boom."

Now the picture is different; we recognize that both quality and quantity are insufficient for the present, and for the future as well. This was brought home to us first by the development during the war of engineered weapons of unprecedented technical complexity, in large quantities, and in great haste, and this initiated a period of technical progress that has abated but little. We have come to recognize as never before that better educated engineers and more of them are needed for advanced developments. In order to help meet these demands, scientists educated to doctoral levels have been called upon to do engineering work; the fact that they often have done it well emphasizes the importance of science in our own curricula and also the need for increased graduate study in engineering.

The question of quantity is not merely one of how to attract talented students into engineering; rather it is one of whether a number sufficient to meet the demand exists at all. Dean Hollister pointed out in his presidential address to the Society, in 1952, that the supply of suitably qualified high school graduates is limited by the size of our population and by I.Q. Assuming that a minimum I.Q. between 115 and 120 is required together with desirable traits of personality, and that qualified high school graduates will have to be shared with other professions, he estimated that we might expect only as many as 40,000 entering freshman engineers. The present enrollment is somewhat greater, but this may reflect lower admission standards. Also the supply and demand for engineers and scientists in future years have been analyzed by Brown, Bonner, and Weir in their book, *The Next Hundred Years*, and they conclude that by the year 2000 —only 40 years from now—the demand will be more than double the available supply.

Nothwithstanding this growing demand and the long range problem it poses, we have seen *decreases* in freshman enrollment of 11.1% and 3.4% in the last two years. This, of course, is a matter of grave concern, especially if, counter to predictions, there should be a further decline. According to the Engineering Manpower Commission of Engineers Joint Council the causes for the decrease are a shifting of qualified ap-

plicants from engineering to science, concern over the rigors and demands of engineering education, and a decrease of applications from students who lack a genuine interest in engineering. Any decrease of applications from less qualified or less well motivated students should not concern us; in fact, we can operate more efficiently without them. However, we may have mixed feelings about a shifting of interest to science. As engineering teachers we naturally deplore any decrease in our enrollment when more engineers are clearly needed; however, from a broader point of view, we may well ask ourselves whether a moderate shift to science is necessarily bad.

The applicant who turns to science may still be a part of our manpower team, if we enlarge our conception of it to include the scientist as well as the engineer and technician. The engineer of course utilizes science but he is not as exclusively concerned with it as is the scientist himself; the engineer is concerned with over-all utility as well. He uses the principles, methods, and knowledge of science in analyzing and synthesizing new systems, but in doing so he has to use judgment and make approximations because he deals with real rather than ideal situations. And when the engineer encounters gaps in scientific knowledge he must proceed on the basis of empirical data and whatever approximations he can find or devise. Moreover, he is the member of the team whose responsibility it is to optimize the design or application so that it satisfies the often conflicting requirements of performance, cost, reliability and producibility; and he may well be the person who sees the need for the new system in the first place. In doing his work the engineer may turn to the scientist for one kind of help just as he turns to the technician for another. Thus, if our conception of the team that makes the advances on the technological front is enlarged to include all three, it is not necessarily undesirable to have a shift in numbers, provided that the total is not reduced and that such a shift puts men in the areas where their best talents and deepest interests lie. I have seen no evidence that the effectiveness of the team as a whole would be impaired by small shifts toward either science or the field of the technician.

Incidentally, the conception of the triform team reinforces the idea that engineering curricula should put great emphasis on science, but also it indicates that this can go too far. It is not that there is any limit to the usefulness of science to the engineer, but rather that there are abilities and attitudes that engineering students must cultivate that are different from those of the scientist, such as the ability to deal with real situations with engineering judgment, and these must not be crowded out by science or by any other part of the curriculum. I hasten to add that the essential part of engineering that I am referring to is not descriptive matter dealing with devices, processes, and how to make standard tests; rather it is learning to deal with new situations with well-ordered analytical thinking. This involves, among other things, recognizing what the real question is, deciding on a plan of attack, making simplifications, carrying out the plan, and checking results carefully.

Increasing the quality of the engineering graduate will require not only a carefully planned undergraduate program but also more emphasis on graduate work, which brings up other questions such as those that concern standards and accreditation in this area, the kind of graduate study most appropriate for engineering, and the place of off-campus and extension programs. Provision is made for the accreditation of graduate programs in ECPD policy but has not yet been undertaken. However, with the rapid expansion of graduate work of the last decade and the urgency for an even greater expansion, the need for accreditation is growing, not only to insure reasonable quality, but also, and more important, to establish as definitely as possible what are proper standards.

The kind of graduate work that is most suitable for engineering needs further study because what has been done is to follow closely the example and pattern of science, which is directed almost ex-

clusively toward competence in research. This is excellent up to a point, for a great many engineers engage in research and, moreover, adherence to the example set by science has had a beneficial influence upon the maintenance of our standards. However, not all of engineering, even at the highest levels, is research, and it may be that we should consider a professional degree which is no less demanding than our present doctorate, but differing from it in conception and purpose much as the M.D. differs from the Ph.D. degree. In addition there is a question of how much specialization we should encourage. The statement is sometimes made that the undergraduate curriculum should be general with specialization postponed to graduate study. But apart from the thesis, which is necessarily specialized, I am sure that specialization has no more place at one level than at another.

Standards are especially involved in the matter of off-campus extension graduate work, which is growing rapidly. This pattern involves a loss of at least part of the values that are believed to come from residence in an academic community: values such as the opportunity to associate closely with mature faculty over a long period of time and over a wide range of interests reaching beyond a single department, the physical facilities of libraries and laboratories that have been designed for education, the variety of courses offered in a number of departments, and the lectures, seminars, and even informal meetings with other wide ranging students. There is also a possible loss in draining some of the best qualified faculty away from the campus, or alternatively, using part-time lecturers from industry.

The problems of quality and quantity lead us naturally to think of how capable faculty may be obtained and how they can be used most efficiently—matters that have been studied by our *ad hoc* Committee on Development of Engineering Faculties. The supply of able teachers depends upon the number of students who are graduating at doctoral levels; our serious difficulty is quickly revealed by a comparison of the number of engineering colleges, almost all of which are seeking faculty, with the annual number of doctorates, only a fraction of the recipients of which enter teaching. Thus there is a need to seek ways of providing more education for some of our present faculty. We also should study more intensively ways of increasing the educational productivity of our faculty which has not changed in centuries, in great contrast with the productivity of engineers themselves. Finally, it would undoubtedly be desirable to study the trends in engineering education itself in order that we may progress more surely and more directly to future goals.

Provision for Leadership

I have tried to outline some of the problems that confront engineering education today and also to point out that they are becoming more difficult and more urgent. If a society such as ours is to provide leadership, we will have to find means to increase our own effectiveness, which as I have pointed out, is best done through studies and research. However, any significant increase of our activity will require a new approach, different from what we have been using. In the past our projects have been generated by individuals or groups of individuals who, working on their own initiative, prepared proposals to be submitted to Council or Executive Board for approval and then to an outside agency for support. Sometimes ASEE is asked to join in support of a project that has already been formulated; in this case we may be glad to participate but it could hardly be said that we are providing leadership—we contribute mainly our name when we ought to be contributing ideas. I am sure that the problems we have studied in the past have been of great importance, but I am not as sure that we always have anticipated all of the most important problems or that we have planned systematically in terms of the whole field of important problems. Our effectiveness would be increased by greater over-all perspective; and undoubtedly there is more that we could do to insure the

fullest implementation of our projects.

It is not easy to find extra manpower in the existing structure of the Society to do some of the things which are needed to provide better leadership. The elected officers comprising the Council and the Executive Board have heavy duties apart from the Society. The Council meets quite infrequently; the Board meets oftener but is burdened with operating problems that consume much of its time. The terms of service of the officers are shorter than the life of projects and this impairs continuity of guidance. And our headquarters staff is minimal, which serves the desirable purpose of keeping expenses and dues low, but does not give margin for new creative work in engineering education.

What is needed is a better mechanism for the promotion of studies and research. I have discussed with the Executive Board and propose to you that we establish a Projects Committee whose purpose it is to make this function of our Society more effective. Such a group should be small, of the order of seven in number, with a turnover period of about four years, comparable to the time that it takes to originate and complete a project, in order to insure sufficient continuity. The committee would be appointed by the Executive Board and would report to it at each of its meetings. It is not just ideas that are needed, but far-reaching ideas, and these often come from the interaction between members of a small group who are individually imaginative and in addition have the opportunity to stimulate each other.

The Projects Committee would be charged with generating ideas for projects to be sponsored by the Society, evaluating ideas that are proposed by individuals and groups within the Society, and devising general policy with respect to projects. It would prepare proposals and assist others in the preparation of their proposals, and would seek financial support from outside agencies. It would follow the progress of studies and research and seek ways of implementing their conclusions when they are completed. In a word, their task would be to initiate, guide, counsel, evaluate and implement. The advantage of this over present procedure would be in fixing responsibility in the Society for a very important task, and providing a mechanism for its execution.

If a Projects Committee is to be effective, it will require time and money; time for two- or three-day meetings, perhaps once a month, or oftener in the initial stages. The cost of the meetings and any supporting assistance may be met by overhead charged to the projects; the initial costs before projects have found support, by a grant from an outside agency, or by Society funds.

In summary I have tried to point out that as engineering itself is growing more and more complex, it is making greater and greater demands on engineering education. And ASEE is pressed harder and harder to provide effective educational leadership. We, like the profession of engineering itself, will have to find more powerful ways to deal with problems of the kind that I have described. As never before there is need for a more powerful leadership; how to achieve it, I submit, is the most important issue before the Society.

STOUT NAMED LEHIGH GRADUATE DEAN

Dr. Robert D. Stout, head of the department of metallurgy at Lehigh University for the past four years, was named dean of the graduate school of Lehigh, effective July 1. He succeeds Dr. Wray H. Congdon, who continues in the post of special assistant to the president.

Quality and Quantity

A Special Report on the 1960 Annual Meeting of ASEE

Quality and quantity were what ASEE achieved at its 68th Annual Meeting at Purdue last June, and quality and quantity were what the Meeting's participants sought for engineering education.

The biggest Annual Meeting in the history of the Society was held at Purdue University during the third week of last June, and it was one of the best. There were 1,534 paid attendees and 571 women and children.

The quality can't be put into numbers, but comments were heard on every side on the value of the papers presented and the great interest excited by the discussions. The JOURNAL will bring the best of those papers to those of its readers who were unable to attend the Meeting, and to those many who heard top-flight papers but were unable to get copies of them at the time.

The significance of the Annual Meeting is indicated by the fact that people were there from eight other countries besides the United States. All fifty states and the District of Columbia were represented, and so were 269 educational institutions, 147 private companies, and 18 government agencies. The Annual Meeting of ASEE is truly the most significant gathering each year for engineering education.

Call for Leadership

The complex problems of getting more engineers and at the same time getting better ones were thoroughly discussed during the week of the Meeting. Dean B. R. Teare, Jr., of Carnegie Tech, President of ASEE for 1959–60, called for powerful leadership in engineering education as the only solution to the twin problems. "It is high time that we bring genuine research techniques to bear on problems in education just as we would in engineering, making use of the most powerful methods of psychology, education, and other relevant disciplines," Dean Teare said. The full text of the Dean Teare's presidential address is presented elsewhere in this issue of the JOURNAL.

Emphasizing the quality aspect, Frank D. Leamer, Personnel Director for Bell Telephone Laboratories, said that basically, the shortage of scientists, engineers, and technicians is not a scarcity of individuals. It is rather a shortage of fully educated potential in these fields. It is well known, Leamer said, that only about one third of the students who rank in the upper half of their high school graduating classes complete a college education. If any large proportion of the remaining two thirds, even though they be predominantly women, become technicians, much of the shortage problem could be solved. In each of these areas in the technological manpower team, the potential remains largely untapped.

Tapping it, of course, requires teachers—again in greater quality and quantity. Harold A. Foecke of Notre Dame University, Project Director for ASEE's Committee on the Development of Engineering Faculties, told a general session that substantially increased numbers of engineering teachers must be found in the next decade if the nation's mounting requirements for engineers are to be met. At present, he said, there is "relatively little activity" in engineering schools in this country either to recruit or develop new teachers. Foecke's report summarized a three-year study of engineering education's most urgent needs. The CDEF study was made by ASEE under Ford Foundation and National Science Foundation grants. The full text of the CDEF report may be found in the May, 1960, issue of the JOURNAL.

Viewing the technological manpower team from a different vantage point, G. Ross Henninger, President of the Ohio College of Applied Science and the Ohio

Mechanics Institute, and the Director of ASEE's National Survey of Technical Institute Education, said the Survey had shown that the much publicized shortage of engineers and scientists is partially an acute shortage of qualified technicians in engineering and science. "An appalling proportion of graduates in engineering and science . . . are . . . continuing to be occupied with work which has evolved out of the engineering sciences into engineering technology."

The engineering technician was called an important part of the craftsman-technician-engineer-engineering scientist team in modern technology by Eric Walker, President of Pennsylvania State University and President of ASEE for 1960–61. President Walker called for a re-evaluation of the nation's educational structure for training the members of the engineering manpower team at both ends of the spectrum. He cited one of the technical institute's major problems as recognition of its value and status. The tendency of traditional colleges to look down upon the technical institute program as not being academically respectable is probably based "in part on misunderstanding," he said. "Certainly, it is based on sheer snobbery. But here in America we can afford to support neither misunderstanding nor snobbery."

Henninger and Walker spoke against the background of a report of the Society's Technical Institute Division which showed alarming soft spots in enrollments in technical institutes. The report, presented by D. C. Metz, director of the Technical Institute at the University of Dayton, showed a drop of 5,100 in full time technical institute student enrollments, for a national total this year of 38,785. This drop was more than made up for by an increase in part-time enrollments, but Metz emphasized that this trend points out "the necessity for vigorous and aggressive action in telling the story of education available for engineering technicians."

Main Objectives

Lest engineering educators become so involved in manpower numbers that they lose sight of the basic challenges facing them, Carl W. Borgmann, director of science and engineering programs for the Ford Foundation, presented some of the broader issues as he sees them in his "cloudy crystal ball." As engineers design devices and produce power for tomorrow's growing world population, can they also design against ignorance, pestilence, hunger, and bigotry? "The engineer cannot escape that special responsibility which derives from his position as father of a new and useful application," Borgmann said. "And each engineer, as part of the profession, has the extra responsibilities to help our nation make wise use of its resources and to help all people, everywhere, to become better able to help themselves."

But even this look into the future and the larger issues came back to the problem of quantity and quality. The primary obstacle in the way of producing engineers who can meet the future's challenge is the difficulty of finding teachers qualified for the necessary kind of engineering education. "A society that adopts and follows the short-sighted policy of placing a low value on educational careers does not plan its future well."

Cloudy though it may have been, Carl Borgmann's crystal ball showed ASEE members some problems that may already be coming out of the future and into the present. Eugene F. Schneider, a vice president of the International Harvester Company, told the Agricultural Engineering Division that a new kind of competition is being developed in industry, a competition of ideas and the men who generate them.

"We must recognize that we now face a competition of ideas which—in some quarters more rapidly than others—must take precedence over our historic competition of products," Schneider said. The situation is made more serious by shortages of the engineers and scientists who have these vital ideas. The company which makes the most of its ideas and its creative thinkers will best survive the shortage, Schneider said, and "considering the state of world affairs, 'nation' could replace 'company' to make the observation even more significant."

The needs of underdeveloped coun-

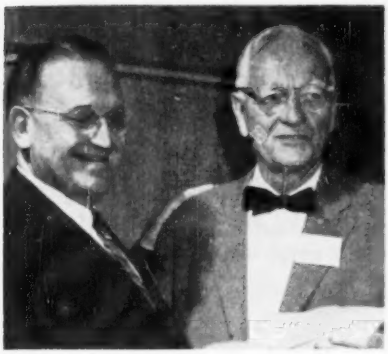
tries as also seen in Borgmann's crystal ball were highlighted by Dr. Jose R. Chiriboga, Ecuador's Ambassador to the United States. Ambassador Chiriboga spoke of Latin America's need for technical know-how and expressed the hope that "American engineering teachers through the American Society for Engineering Education will take an active part in this crusade for the technical development of Latin America—especially now that we are witnessing in other continents a vigorous economic development to utilize the benefits of technological discoveries."

Facilities Unmatched

The facilities provided for the Meeting by Purdue University were up to the Meeting's rating as biggest and one of the best. The Purdue Memorial Union and Memorial Center were ideal, and the arrangements made by the local committees were well organized and well administered, under the direction of L. M. Vallely, general chairman, and M. D. Roberts, vice-chairman and chairman of the co-ordinating committee. The other committee chairmen were J. H. Porsch, planning and idea committee and displays and exhibits committee, W. J. Freehafer, finance committee, J. N. Arnold, final report committee, W. J. Luzadder, attendance promotion committee, Howard Gillespie, publicity committee, G. W. Bergren, registration committee, J. C. Smalley, housing committee, F. W. Stubbs, Jr., off-campus transportation committee, W. S. Fletemeyer, campus transportation committee, J. H. Hicks, inspection trips on-campus committee, Mrs. G. A. Hawkins and Mrs. E. A. Trabant, women and young people's program committee, O. D. Roberts, hospitality committee, E. A. Trabant, entertainment committee, D. E. Bloodgood, banquet and special meal committee, J. W. Hancock, ticket committee, Dr. L. W. Combs, health, insurance and security committee, J. F. Blakesley, session commitee, J. A. Ritchey, information committee, and A. J. McAllister, Greater Lafayette committee.

The only cloud on the Purdue horizon was the ill health of L. M. Vallely, general chairman for the Meeting, and of Dean Emeritus A. A. Potter of Purdue,

Professor Ali B. Cambel of Northwestern University (second from left) feels that the Annual Meeting should be a family affair. Dean Teare (left), the registration clerk, Mrs. Cambel, and the four young Cambels appear to agree.



James S. Thompson, retired vice-chairman of the board of the McGraw-Hill Book Company and a past Treasurer of ASEE, was made an Honorary Member of the Society at the Annual Meeting at Purdue. Dean B. R. Teare, Jr., ASEE President for 1959–60, is shown presenting Mr. Thompson a copy of the citation.

who is the earliest of ASEE's past presidents still living. The thorough planning and organization of Mr. Vallely enabled Dean G. A. Hawkins to take over the reins without difficulties.

A Family Affair

The ASEE Annual Meeting is traditionally a family meeting, with ample arrangements for wives and children of members to enjoy themselves while Pop goes to meetings, and with social events for the whole family when Pop can be with them. Purdue upheld the tradition well, with such highlights as a chicken barbecue on Wednesday. Tours, teas, a mixer, swimming, plays, golf, receptions, and other events filled the week with enjoyment for the families.

Those with an eye for the future could also visit the Kentucky hospitality room and get a preview of what is coming up for the 1961 Annual Meeting in Lexington. No figures are available for the total number of visitors to the Kentucky room, but a reliable informant says that a total of 793 visitors asked where was the bourbon part of the hospitality. It was enough to drive the Kentucky delegation to drink—water.

Eric A. Walker

(*Continued from page 7*)

guided torpedo and received the Navy Distinguished Public Service Award in 1958. Other awards include the Distinguished Service Medal of the Pennsylvania Department of the American Legion, the Horatio Alger Award, and the Tasker H. Bliss Award of the American Society of Military Engineers.

In addition to his public and educational activities, Eric Walker has a long and distinguished record of technical and administration consulting with research and industrial firms.

As a teacher and educational administrator, Eric Walker is particularly proud of his part in establishing at Penn State the two-year associate-degree program for training technical aides and the Engineering Science Curriculum, an honors program to prepare outstanding young engineers for positions of leadership in today's technological society.

A firm believer in the importance of physical fitness, Eric Walker seeks relaxation in a wide variety of sports, including, especially, squash in the winter months and tennis during the summer. Since becoming President of Penn State, he has earned his private pilot's license and often flies himself to meetings and conferences. He is an omnivorous reader, an enthusiastic philatelist, and at least an adequate organist. His associates at Penn State find only one fault with him: they confess it is impossible for them to maintain the pace he sets for himself.

What's Going On in ASEE

A Narration of Major Actions of the Executive Board and General Council at their June Meetings

W. LEIGHTON COLLINS, *Secretary, ASEE*

Final action on individual membership applications brought the total for the year to 972. This compares favorably to the previous three-year average of 961. A return from about 30% of the member institutions indicates that only about 50% of the full-time staff members of colleges of engineering are members of ASEE. Next year's membership campaign will be conducted through the Sections and institutional representatives. Some statistics for the members joining during the year follow:

DEGREE ANALYSIS OF 972 APPLICANTS FOR MEMBERSHIP JULY 1, 1959-JUNE 28, 1960

	Age	
Degree	36 and Over 514 or 53%	Under 36 458 or 47%
None	6.2	1.1
B.S.	18.8	29.5
A.B.	3.5	2.2
M.S.	28.7	35.0
M.A.	7.3	2.2
Ph.D.	21.0	17.7
D.Sci.	2.7	1.5
Other	11.7	10.9

124 from non-educational institutions.....13%
210 from other than active member institutions.....20%

Industrial membership was approved for three companies, bringing the total to 187: 1. Carrier Corporation 2. Varian Associates 3. Wisconsin Motor Corporation

San Diego State College was approved as an Affiliate member and the Nova Scotia Technical College was declared eligible for active membership.

Life membership was approved for 20 members bringing the total for the year to 45. The following members are listed as "address unknown;" thus we can't send them the JOURNAL or dues notices and they probably will have to be dropped at the end of the year. If you have information on any of them please send it to the Secretary's office.

Alphonso Ambrosio
Sidney R. Blair
E. S. Borgquist
J. Ansel Brooks
Ellsworth A. Brown, Jr.
Stanley C. Brown
Arvid W. Carlson
Morton A. Coyne
Patricia H. Eyer
Lindley E. Flanagan, Jr.
Gordan M. Goudey
George W. Haas
Walter W. Halcomb
Ray A. Harrold
Frank L. Holman, Jr.
Philip S. Horne
Bernard A. Huffman
Harry S. Imming
Frank J. Janza
Roger F. Klein
Leroy Joseph Krzycki
Richard Bernard Ladner
Lloyd D. Lee
Robert Charles McCollum
Lloyd S. Moore, Jr.
Richard Bullis Norman
Herbert A. Osterkamp
Nicholas A. Pananides
Aladdin N. Perkins
Donald A. Ringe
Ren G. Saxton
F. W. Walsh
Burdett W. Warner
Adrian J. Westbrock
Robert M. Williams

The deaths of 61 members were reported during the year. Resignations totaled 214, the highest in three years. The drops from membership for nonpayment of dues for two years totaled 211, 65 in the under 36 years of age category and 146 in the older group. This is a considerable increase over the 160 average for the previous three years.

Budget

A budget of $140,860 for 1960–61 was approved. This is 6.5% greater than the one for the current year and is based on a growth equal to three-fourths of that of 1959–60. This means that everyone must continue to do his share of ASEE promotional activities. The level of articles in the JOURNAL OF ENGINEERING EDUCATION has gone up, the programming for Annual Meetings has improved, and the recognized stature of the Society as reflected by its special projects is higher than ever before! You do have something to sell.

The Emergency reserve fund was increased from $75,000 to $90,000, due primarily to unexpected and unbudgeted income from special projects—salary recoveries and recovery of indirect costs. It also was decided that an audit be made to determine the indirect cost percentage for the Society.

The Machine Records Committee reported that considerable savings could be made by using IBM card data and offset printing for the Yearbook-Directory. The Executive Board voted to authorize the Committee to proceed with the conversion of the Yearbook-Directory data to a punch card system and with studies of other aspects of Society operations.

Projects

The actions taken in getting the Undergraduate Equipment Survey underway were approved. The study was made at the request of the National Science Foundation. ASEE was not asked for an endorsement of the program; nor has it discussed the desirability or feasibility of such a program.

The receipt of a grant of $16,000 from the Ford Foundation for an opinion survey, regarding graduate work and engineering teaching as a career, of Tau Beta Pi members, was made a matter of record. This is a continued activity of the Committee on Development of Engineering Faculties and will be directed by H. A. Foecke.

A proposal for the "Evaluation of Non-Resident Graduate Work in Engineering" was approved for submission to a foundation. The budget is $110,000. This is a follow-up and outgrowth of one aspect of "Facilities and Opportunities For Graduate Study In Engineering" published in 1958 and needs to be made because that type of graduate work has been growing so rapidly during the past few years.

The Visiting Engineers Committee was authorized to seek funds for an extension of its program beyond January 1, 1961, in order to accommodate the large number of requests for visits. The National Science Foundation provided funds for the current program.

There were so many well qualified applicants for Iowa State University's summer institute, "Nature and Properties of Materials," that its request for ASEE cosponsorship, without financial responsibility, of a repetition of its current program in the summer of 1961 was approved. It is hoped other institutions will initiate programs in this vital area of engineering.

The invitation of the Engineering Activities Board of the Society of Automotive Engineers to cooperate with and cosponsor, without financial responsibility, the development of a session on the break-through in engineering education at SAE's annual meeting in Detroit on Jan. 9–13, 1961, was approved.

The Executive Board reaffirmed its interest in a foreign visitors project and the Secretary and Vice President for Instructional Divisions were instructed to proceed with developing a proposal.

On the recommendation of ECAC, a resolution was approved which establishes the interest and concern of ASEE in the effectiveness of the many counseling and guidance programs supported by Federal funds in the areas of mathematics, science, and engineering and reaffirms the offer of ASEE of its wholehearted support through the ECPD Guidance Committee to make each Institute as effective as possible by assistance, upon request, in orienting the trainees in a fuller appreciation of the major fields in engineering and science. As one result of its study of its organizational structure and functioning ECAC decided to limit its activities to the area of administration.

A few changes in the Constitution and By-Laws were approved by the General Council. They remove an inconsistency

of wording regarding the increase of dues by the General Council within the ceiling limits and remove the designation of committees from the By-Laws. The changes now go to ECAC and ECRC for approval prior to submission to the individual members.

It was agreed that planned bus trips with guides to scenic spots should be planned for the one or two days immediately before and after the 1962 Annual Meeting at the Air Force Academy.

Project Management Committee

At the suggestion of President B. R. Teare, Jr. and President Elect E. A. Walker it was voted that a "Project Management Committee" of about seven members be appointed and that $5,000 from the unallocated reserve be appropriated for one year's operation. The purpose of the Committee will be to initiate proposals for foundation support, get the grants, pick the project directors, and after the projects are completed put them in the hands of those responsible for implementation. The seven people on the group must agree to spend 10 to 20 days per year at meetings. Travel expenses, but no stipends, are to be paid.

The International Relations Committee will become an ASEE committee, instead of an ECAC, on the recommendation of ECAC. It also was recommended that a study be made of the possible reorganization or combination of ASEE's committees on National Legislation and Relations With the National Science Foundation and ECRC's Committee on Relations With the Federal Government. ECRC also announced the formation of an Interdisciplinary Research Committee and a new basis for membership eligibility.

P. T. Bryant, Editor of the JOURNAL OF ENGINEERING EDUCATION, proposed the development of a series of radio or TV programs to orient high school students in regard to the nature of engineering. A series of 10 films, Horizons of Science, has been prepared by the Educational Testing Service with the assistance of a pilot grant from the National Science Foundation. The Executive Board voted that Mr. Bryant continue his study of a radio, TV, or radio and TV series, that he inquire about it at various institutions, that he develop a broad picture of bringing information to high school students, and that he explore the cooperation and interest of the various ASEE and ECAC committees, as well as of ECPD.

Teaching Positions Available

Because of the number of requests from non-members of ASEE for information on how to find out about teaching openings, the JOURNAL OF ENGINEERING EDUCATION henceforth will carry a new classified ad section on "Teaching Positions Wanted." The cost will be $2.00 per line, the same as for the "Teaching Positions Available" section.

Summer schools approved are:

1961—*Aeronautical Engineering Division*—A one-day program in connection with the Annual Meeting to discuss curriculum matters.

1962—*Chemical Engineering Division*—Its regular 5-year summer school at the University of Colorado, August 20–25. The purpose is to bring chemical engineering teachers together to present new ideas and concepts in the teaching of chemical engineering subjects. It is proposed that a grant from the National Science Foundation be sought to finance the program.

On the recommendation of the Annual Meeting Committee it was voted that the location of the following Annual Meetings be approved: 1964—University of Maine; 1965—Illinois Institute of Technology

President Elect E. A. Walker stated that for the next meeting of the General Council he wanted to have a discussion of ways and means of making the General Council more effective. Because of its size and infrequent meetings it now serves primarily as an "approval of reports" body. Future meetings are:

Executive Board—Sept. 21, 1960; Chicago, Ill.
Nov. 17, 1960; Washington, D. C.

General Council—Nov. 16, 1960; 12:00 o'clock noon; Washington, D. C.

Citations for Honorary Membership

Honorary members are chosen "from among those who have rendered eminent service to mankind in engineering education or other engineering fields." Election is by favorable vote of at least three fourths of the General Council. No more than two can be elected in a given year.

HENRY TOWNLEY HEALD

Following several years of experience in structural design in railroading and in city development you have made a career of teaching and educational administration, occupying increasingly responsible positions to and including the Presidency of an engineering college and the Chancellorship of a great university.

Throughout this period you have shown a high regard for ethical practices and insisted upon the teaching of the broad responsibilities of the engineering profession as well as the technical details.

In addition, you have been a participant and a leader in civic activities of wide variety and scope, including city development, safety education and improvement, the advancement of the profession of engineering through committee and society activities. You have held offices, frequently including the presidency or chairmanship, in numerous regional and national engineering and welfare organizations, including the presidency of this society, and you now direct one of the nation's largest and most active philanthropic and welfare foundations.

In recognition of this noteworthy career, the American Society for Engineering Education has elected you its fifth Honorary Member.

JAMES STACY THOMPSON

Upon graduation from the University of Wisconsin you joined the staff of a young but growing engineering-book publishing house. You started your career as a publisher by visiting engineering schools throughout the United States and Canada seeking new books for publication and recommending improvements in textbook selection. During succeeding years you advanced in your organization through the offices of Manager of the Educational Department, Secretary, Vice President, President, and Vice Chairman of the Board of Directors.

Throughout these years you held before yourself and your associates the high objective of ever improving technical books for instruction purposes. During the period of your publishing service, and to a great extent through your efforts and direction, your company produced many of the best known and most widely used textbooks and series of textbooks for the field of engineering education.

You have been a member of the American Society for Engineering Education since 1911. In addition to various committee assignments, you served as the Society's Treasurer for eight years, and on its General Council for twelve years.

In recognition of your devotion to the improvement of engineering education through the conception and production of useful text and reference books the American Society for Engineering Education has elected you its sixth Honorary Member.

THE LAMME AWARD

The Lamme Award consists of a gold medal and bronze replica bestowed annually upon a distinguished engineering educator for excellence in teaching and contributions to the art of teaching; contributions to research and technical literature; achievements which contribute to the advancement of the profession; and engineering administration. The Lamme trust fund was established in memory of Benjamin Garver Lamme.

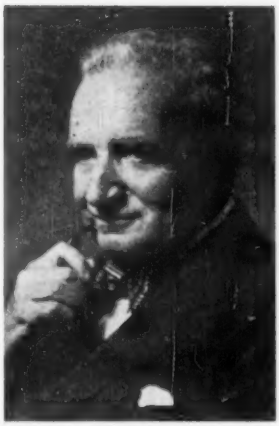
THEODORE von KARMAN has long been considered one of the foremost aeronautical scientists, and has been accorded world-wide recognition for his research achievements and personal leadership in mechanics, aerodynamics, and associated fields. His great number of publications, his fundamental contributions to theory and experiment, his research institutes on two continents, his directorship of AGARD and its influence on international security, all contribute to the breadth and pre-eminence of his achievements.

Born in Budapest, Hungary, May 11, 1881, the son of a famous teacher, Dr. von Karman was graduated with highest honors from the Royal Technical University at Budapest as a mechanical engineer in 1902. He practiced with the Ganz Company for three years, returning to the academic life for study in mathematics, physics, and mechanics at the University of Gottingen, where he received the Ph.D. in 1909 and taught as Assistant Professor until 1912. He then became Professor of Aeronautics and Director of the Aeronautical Institute at the University of Aachen, Germany, a post which he filled brilliantly until 1930, developing an outstanding aeronautical center.

After a lecture tour to the United States in 1926 under the auspices of the Daniel Guggenheim Fund for the Promotion of Aeronautics, a series later extended around the world, he acted for some years as a visiting professor in this country, Japan, China, and India. In 1930 he came permanently to Pasadena, California, joining the faculty and heading the Guggenheim Aeronautics Laboratory at the California Institute of Technology. There he built up a second great research institute, combining theory and experiment in a new type of engineering science, and evolving a new generation of aeronautical engineers who could apply the results of fundamental thought to the practical problems of the supersonic age.

From 1939 he served as consultant to the Air Force, and in 1944 organized and served as Chairman of the Advisory Board to the Commanding General, where he again brought scientific methods to military research and development, planning, and operations. After World War II he was largely responsible for the establishment of an Advisory Group on Aeronautical Research and Development (AGARD) within the North Atlantic Treaty Organization. He was unanimously elected its first Chairman, and has been twice re-elected; here he has greatly furthered cooperative aeronautical developments among the NATO

To THEODORE VON KARMAN, *engineer, scientist, teacher, administrator, and world citizen; for his outstanding, creative, and inspiring teaching; for his development of superior engineering educational and research programs in both Europe and America; for his pioneering writings; for his interpretation and application of advances in engineering and science; for his contributions to national security and international peace; for his great humanitarianism, warm personal qualities, and keen personal insight, we present this thirty-third Lamme Award.*



nations and forces in support of world peace and security.

Throughout his career, Dr. von Karman has made significant contributions both as an individual and as a team member in many fields, notably applied mathematics, physics, strength of materials, stress analysis, and the theory of elasticity, including elastic stability, monocoque structures, and vibrations; the mechanics of ideal, viscous, and compressible fluids, turbulence, and the aerodynamics of aircraft; the hydrodynamics of planing surfaces; heat transfer, combustion, and rockets.

While the four volumes of his collected works (London, 1956), well over one hundred published papers, reflect the variety of his scientific interests, they omit much of his consulting work. This has dealt with important projects ranging from airplanes to suspension bridges and windmills, and from helicopters to rocket propulsion. His unpublished reports in the files of many industries and governments, together with the further work stimulated by his suggestions, represent a very large contribution to our modern technology.

Most important of all, however, has been his personal inspiration, guidance, and encouragement to countless students and fellow-workers. They have responded, as all who know him do, to his warm friendliness, his great intellectual powers, his penetrating intuition, his accurate judgment, and his tremendous personal and scientific stature.

1928—George F. Swain
1929—Irving P. Church
1930—Charles F. Scott
1931—Dugald C. Jackson
1932—Arthur N. Talbot
1933—Dexter S. Kimball
1934—Edward R. Maurer
1935—William E. Wickenden
1936—Herman Schneider
1937—Frederick E. Turneaure
1938—Robert L. Sackett
1939—Stephen P. Timoshenko
1940—Audrey A. Potter
1941—Anson Marston
1942—Roy A. Seaton
1943—Thomas E. French
1944—Hardy Cross
1945—Harry P. Hammond
1946—Robert E. Doherty
1947—Warren K. Lewis
1948—Alexander G. Christie
1949—Karl T. Compton
1950—Fred B. Seely
1951—Allan R. Cullimore
1952—Solomon C. Hollister
1953—Harry S. Rogers
1954—Thorndike Saville
1955—Vannevar Bush
1956—Llewellyn M. K. Boelter
1957—William L. Everitt
1958—Linton E. Grinter
1959—Gordon S. Brown

THE GEORGE WESTINGHOUSE AWARD

The George Westinghouse Award was established by the Westinghouse Educational Foundation in 1946 as an annual award to young engineering teachers of outstanding ability to recognize and encourage their contributions to the improvement of teaching methods for engineering students. The award consists of $1,000 in cash and an appropriately engraved certificate.

ROBERT BYRON BIRD was born in Bryan, Texas on February 5, 1924. He became interested in engineering and in academic work through the influence of his father, who is a distinguished civil engineer.

Dr. Bird received his B.S. degree in Chemical Engineering from the University of Illinois in 1947. His undergraduate work was interrupted by a three-year period of service in the Chemical Warfare Service, 1943–46. He rose to the rank of First Lieutenant and was awarded the Bronze Star Medal for meritorious service in combat in Germany.

His graduate training was in the field of physical chemistry taken at the University of Wisconsin, from which he received his Ph.D. in 1950. This was supplemented by a year at the University of Amsterdam as a Fulbright Fellow, 1950–51, and by a year as Project Associate in Chemistry at the University of Wisconsin, 1951–52.

Dr. Bird's teaching career began as an Assistant Professor in Chemistry at Cornell University, 1952–53. He then was invited to join the Department of Chemical Engineering, University of Wisconsin, as a Project Associate, with the assignment of developing a more fundamental approach to those problems of chemical engineering which involve the transfer of momentum, mass, and heat. In 1955, he was made Associate Professor, and in 1957, at the unusually early age of 33, was promoted to a full professorship, which position he now holds.

The research contributions of Dr. Bird have been made in the field of molecular theory of gases and liquids with particular reference to their transport properties, and in theoretical developments in fluid mechanics, heat transfer, and mass transfer. Through application of the Navier-Stokes equations, he has made important extensions of theories in the fluid mechanics of non-Newtonian fluids, and in heat and mass transfer. He developed important engineering principles in calculating the flow of plastics in extrusion processes, and heat transfer to non-Newtonian fluids.

To ROBERT BYRON BIRD, *for his challenging and inspired teaching; for his brilliance and enthusiasm in translating basic science into engineering procedures, and in introducing new concepts into engineering education both here and abroad; for his original and scholarly textbooks; for his leadership in improving chemical engineering education at both the undergraduate and graduate levels; and especially for his constant and unselfish devotion to the interests of students; we present this fifteenth George Westinghouse Award.*

The results of his researches are given in some 40 papers, published in scientific and engineering journals not only in this country, but also abroad. He is co-author of two books, *Molecular Theory of Gases and Liquids* (1954), and *Transport Phenomena* (1960). The latter is receiving widespread attention among engineering educators, and already is exerting a marked effect on curricula and instruction in chemical engineering. He received the Curtis W. McGraw Research Award of the Society in 1959 for his outstanding research achievements.

Lectures on a variety of chemical engineering subjects have been presented by Dr. Bird to university groups, to technical societies, and to the technical staffs of various companies, both in this country and abroad. In 1957, he was invited to present a lecture on "Teaching of Transport Phenomena" at the Conference of Deans of Engineering. During the second semester of 1957–58, he held a Fulbright Lectureship at Delft, Netherlands.

Dr. Bird is one of those rare individuals who is brilliant and provocative in both teaching and research. He has unusual ability as a linguist, with a reading and speaking knowledge of Dutch, German, and French and a reading knowledge of Russian. When holding the Fulbright Lectureship at Delft, he delivered all of his lectures in Dutch. He is an accomplished organist, with a particular interest in the music of Bach. He is an outdoor enthusiast and has taken many extensive cycle and canoe trips.

1946–James N. Goodier
1947–B. Richard Teare, Jr.
1948–Hunter Rouse
1949–Joseph Marin
1950–Rolf Eliassen
1951–Glenn Murphy
1952–Gordon S. Brown
1953–Edward F. Obert
1954–Thomas J. Higgins
1955–Robert R. White
1956–Milton C. Shaw
1957–Robert E. Treybal
1958–Willis W. Harman
1959–Max S. Peters

THE VINCENT BENDIX AWARD

The Vincent Bendix Research Award consists of a gold medal and citation conferred annually for outstanding research contributions, either in original thought or administrative leadership, to a staff member of the colleges of engineering in the United States. The award was established through the efforts of the Engineering College Research Council and the Bendix Aviation Corporation. The latter granted funds to establish the award in 1956

MAURICE J. ZUCROW, Atkins Professor of Engineering, Purdue University, has been in charge of instruction and research in gas turbines and jet propulsion since its inception in 1946.

The Jet Propulsion Center of Purdue University, first in the country devoted exclusively to instructional research, is peculiarly the product of his genius and enthusiasm—founded upon his belief in the rocket jet as the aircraft and missile power plant of the future and his conviction that varied phenomena relating to rocketry would long provide fresh challenges for research.

Through intimate liaison with industry and governmental agencies he has selected basic problems within the capacity of graduate students so that significant contributions to knowledge have been made in the process of training research engineers. Notably the Center has led the rocket engine industry into the use of higher pressures and novel methods of cooling, resulting in greater power from available fuels.

It is characteristic of Dr. Zucrow that his outlook is much broader than that of the successful researcher. He has an intense interest in engineering design and is providing primary leadership today in this area as chairman of the Design Committee of the School of Mechanical Engineering. His stimulating influence in the field stems from his ability to solve complex problems by the application of essential fundamentals. He believes in exercising a student's mind in the power of a principle.

Twenty-one Ph.D. degree theses and fifty master's degree theses have been completed at the Center. The excellent quality of graduates with training at the Center is recognized throughout the jet propulsion industry and many occupy positions of considerable responsibility. A warm camaraderie exists between Dr. Zucrow and those graduates. It is said that he has disciples rather than students. His visit to localities where they are employed is usually the signal for a social gathering and a lively exchange.

Dr. Zucrow was born near Kiev, Russia, in 1899. He graduated *magna cum laude* from Harvard University in 1922 and received his master's degree the fol-

To MAURICE J. ZUCROW, *research engineer, teacher, and respected protagonist, for his exploitation of basic research in the field of jet propulsion; for his genius in stimulating and disciplining the creative endeavors of young research engineers; for the vigor of his intellect, the enthusiasm of his spirit and the prodigious and ever-renewed accomplishment of his mature years; for founding and directing the Purdue University Jet Propulsion Center; for participation in affairs that are vital to the competitive strength of our nation; for his notable contributions to the literature of jet propulsion and missile design, we present this fifth Vincent Bendix Award.*

lowing year. He taught thermodynamics and mechanics of fluids, and mechanical vibration at Purdue University, until 1929 while completing the work for the Ph.D. degree which he received in 1928 –the first Ph.D. degree in engineering granted by Purdue.

From 1929 to 1934 he was Vice President of Paragon Vaporizer Corporation, in charge of engineering. He developed carburetion equipment for burning heavy fuels in spark-ignition engines. This was followed by three years as a partner in Hubbard Engineering Company, consultants in electric and water utilities.

He was subsequently engaged in manufacture of instruments and control devices as General Manager of Ring Balance Instrument Company, followed by two years in thermodynamic design of gas turbines with the Elliott Company, before joining the Aerojet Engineering Corporation.

It was with Aerojet in Azusa, California, as technical assistant to the Executive Vice President, that he became deeply involved in the field of rocketry. Here he was in charge of technical phases of solid propellant and Jato production, and general preliminary design of rocket propulsion equipment.

He has had many responsibilities, nationally, in jet propulsion. He is currently a member of the Ordnance Scientific Advisory Committee, Department of the Army; the board of directors of the American Rocket Society, and the advisory panel to the Committee on Science and Astronautics of the House of Representatives.

Dr. Zucrow is author of *Gas Turbines and Jet Propulsion*, 1948; Co-author of *Principles of Guided Missile Design*, 1956. His two-volume work, *Aircraft and Missile Propulsion*, 1958, written primarily for students, has become a prime reference for professional engineers.

1956–Clifford C. Furnas
1957–Theodore von Karman
1958–Hunter Rouse
1959–Robert F. Mehl

THE CURTIS W. McGRAW AWARD

The Curtis W. McGraw Research Award was established to recognize outstanding early achievements by engineering college research workers and to encourage the continuance of such productivity in the future. The award was sponspored by the Engineering College Research Council with the assistance of the McGraw-Hill Book Company. The award consists of $1,000 in cash and an appropriately engraved certificate.

ALI BULENT CAMBEL was born of Turkish parents on April 9, 1923, and became a U. S. citizen in 1951.

He obtained his first degree in 1942 in the Liberal Arts at Robert College in Istanbul, Turkey. Subsequently, he studied chemical engineering at the University of Istanbul. Arriving in the United States, he studied mechanical engineering and naval architecture at the Massachusetts Institute of Technology. He attended the California Institute of Technology where he received the degree of M.S. in 1946, after which he studied at the University of Iowa, where he earned the Ph.D. degree in 1950.

Dr. Cambel's teaching career began in 1947 as an Instructor in Mechanical Engineering at the University of Iowa, where he rose to the rank of Associate Professor of Mechanical Engineering. He joined the faculty of Northwestern University in 1953 as Associate Professor of Mechanical Engineering, being promoted to full Professor in 1956. In 1957 he was appointed Chairman of Northwestern's Mechanical Engineering Department, which position he now holds.

Dr. Cambel's professional interests have been in gasdynamics with particular emphasis on problems which transcend rigid disciplinary lines. Thus, he has done extensive research in aerothermochemistry, combining fluid mechanics, thermodynamics, heat transfer, and chemical reaction kinetics. Presently he is extending his work to magnetohydrodynamics and plasma physics.

At Northwestern University he developed a unique laboratory for research into the various aspects of gasdynamics and magnetohydrodynamics. Working closely with an enthusiastic group of graduate students, he has spearheaded the development of simple but versatile laboratory facilities. In spite of the sophistication of these experiments he has succeeded in interesting undergraduate students even on the freshman level in participating in the various research activities. Much of Dr. Cambel's research forms the basis of pioneering

To ALI BULENT CAMBEL *for his original research and contributions to the literature in different aspects of gasdynamics; for originating with his students new concepts and methods in high velocity flame stabilization; for developing a research program which attracts a large group of graduate students who enthusiastically pursue research in aerothermochemistry, magnetohydrodynamics and plasma physics; for his inspiring teaching of the newer fields which only a few years ago were in the realm of pure science and for his leadership in mechanical engineering education, we present this fourth Curtis M. McGraw Research Award.*

courses which he introduces in spite of the lack of suitable textbooks.

The author and co-author of many papers, Dr. Cambel has co-authored *Gas Dynamics*, published by the McGraw-Hill Book Company in 1958. He is also co-editor of the Proceedings of the Gas Dynamics Symposia, which are held biennially under his leadership. He has been an invited lecturer at many of the nation's engineering schools and research laboratories.

Active in professional society activities, Dr. Cambel has been Chairman of the Heat Power Sub-Division of the ASEE and currently is serving as the Secretary of the Mechanical Engineering Division. A prominent member of the American Rocket Society, he was elected to Fellow membership in 1955 and to the Society's Board of Directors in 1960. He has been Vice-Chairman of the Combustion and Propellants Technical Committee and presently is serving as the Chairman of the Magnetohydrodynamics Technical Committee. He is an Associate Editor of the *ARS Journal*. In 1959 the American Rocket Society awarded to Dr. Cambel the J. Edward Pendray Award for his outstanding contributions to the scientific literature. Earlier he received a leadership award from the YMCA.

Widely read and widely travelled, Dr. Cambel is the father of four children, and weekends find the whole Cambel family taking bicycle trips along Lake Michigan.

1957—George Gerard
1958—C. M. Sliepcevich
1959—R. Byron Bird

Other ASEE Awards

Besides the four major awards presented at the Annual Banquet at Purdue on June 23, three other awards were presented at the Annual Meeting for distinguished performance in specific areas of engineering education.

The James H. McGraw Award

Each year the Technical Institute Division of the American Society for Engineering Education presents to an outstanding contributor to technical institute education the James H. McGraw Award. Established in 1950 by the McGraw-Hill Book Company in memory of James H. McGraw, the award consists of $500 and an appropriately engraved certificate.

The award for 1960 went to Kenneth L. Holderman, Coordinator of Commonwealth Campuses for Pennsylvania State University and a member of ASEE since 1945.

Engineering Graphics Distinguished Service Award

The Distinguished Service Award is presented by the Engineering Graphics Division of ASEE to express the deep appreciation of the Division and to acknowledge by means of a certificate and a citation the distinguished services rendered by the recipient as a teacher of engineering graphics.

The award for 1960 went to Clifford H. Springer, Professor of General Engineering at the University of Illinois and a member of ASEE since 1927.

Engineering Graphics Nomography Award

The Nomography Award is presented for the best nomogram published during the past year. This year the award is made with the cooperation of the *General Motors Engineering Journal.*

The Nomography Award of $100 was presented this year to R. L. Patton, Supervisor, Equipment Design and Selection, Gulf Oil Corporation, Port Arthur, Texas, for "Velocity of Steam in Pipes," in the September 1959 *Plant and Power Services Engineer,* page 43.

JOURNAL ACCEPTING TEACHING POSITIONS WANTED ADVERTISING

Teaching Positions Wanted advertising is now being accepted by the JOURNAL OF ENGINEERING EDUCATION as a new service to its members and to others interested in entering the engineering teaching field. Any individual seeking a teaching position, regardless of membership in ASEE, can now purchase space in the JOURNAL at the regular rate of two dollars per line. This new service is expected to be especially valuable to those not now in engineering teaching who would like to enter the field. In the past there have been ample avenues for the teacher to seek opportunities outside of teaching, but the engineer in industry or the armed services has not had full opportunity to seek positions in teaching.

The new advertising feature was authorized at the June, 1960, meeting of the Society's Executive Board.

The Technical Institute in America

G. ROSS HENNINGER

Director of the Survey
President
Ohio College of Applied Science
and Ohio Mechanics Institute

Specifically, my assigned topic for this occasion is "The Major Findings of the Survey." "The Survey" refers to the National Survey of Technical Institute Education, recently conducted for the American Society for Engineering Education under a supporting grant from the Carnegie Corporation of New York.

History and Scope of Survey

The idea of the Survey was conceived and adopted by the ASEE Technical Institute Division in 1954. The purpose was to bridge the thirty-year gap since the Wickenden-Spahr ASEE survey, and to determine the present status and potential of technical institute education. With the understanding support of the ASEE General Council and its secretary, the idea was developed into a detailed formal proposal, approved by the General Council, and endowed with financial support during 1955. The work up to this point was executed by the ASEE Technical Institute Study Committee consisting of Kenneth L. Holderman of The Pennsylvania State University, Leo F. Smith of the Rochester Institute of Technology, Karl O. Werwath of the Milwaukee School of Engineering, and G. Ross Henninger then of Iowa State College, operating under the dynamic chairmanship of Edward E. Booher of the McGraw-Hill Book Company, Inc.

In 1956, with the project financed and ready to go, the Study Committee established a Survey Project Committee to develop and carry through all operational phases of the project including the preparation and publication of a comprehensive report. This committee as established consisted of H. Russell Beatty of Wentworth Institute, Maynard M. Boring of the General Electric Company, C. J. Freund of the University of Detroit, George A. Gullette of North Carolina State College, Robert L. Shurter of Case Institute of Technology, and Leo F. Smith, operating under the inspiring chairmanship of Kenneth L. Holderman, with G. Ross Henninger released by Iowa State College to serve as Executive Director of the project. During 1956, this group translated the Proposal into a complete and detailed program of field operations, logistically balanced to function on a national basis.

During 1957, the field work was conducted and the assembly of information (8 file drawers full) was completed. This was accomplished through fourteen regional committees functioning in parallel. These regional committees operated on an intimately co-ordinated basis under a common program structure, but with full and responsible autonomy for the conduct of local work and the exercise of local brain power. As 1959 drew to a close, the report of this activity came off the presses and, as 1960 opened, was distributed through the mails. Also, it went into the general book markets in a hard-cover edition, as a unit of The Carnegie Series in American Education pub-

A summary of major findings of the recent National Survey of Technical Institute Education conducted for the American Society for Engineering Education under a supporting grant from the Carnegie Corporation of New York. Prepared as one of four parts of a panel program for the Annual Meeting of the American Society for Engineering Education at Purdue University, June, 1960.

lished by McGraw-Hill in recognition of their importance to the future of American education.

This report [1] is no one-man brainchild; nor yet a one-committee brainchild. It represents the consolidated results of 143 persons representative of education, industry, and the engineering profession, who made up its several working committees, and who contributed more than 753 man-days of time and traveled a total of 125,182 man-miles in the fulfillment of their Survey work. These people, normally operating in teams of two, visited and conducted interviews at 90 educational institutions in 39 states and at 140 industrial enterprises or other employers of technological personnel in 25 states. These visits also included schools and industries in the state of Nuevo León, Mexico, and the provinces of Ontario and Manitoba in Canada. They were generously aided by the people at the schools and industries visited. Of such is this Survey Report. It bridges the thirty-year gap since the Wickenden-Spahr report. It provides a solid basis for necessary developments in the total educational enterprise concerned with the rapidly growing field of engineering and the related sciences and technologies.

Summary of Salient Findings

This brief review of the scope and nature of the Survey provides an appropriately orienting background against which to present some of the more significant findings. Subject to the inevitable risks of over-simplification, these may be briefly stated as follows:

1. It confirmed the fact, also reflected in the findings of the President's Committee on Scientists and Engineers, that the much publicized shortage of engineers and scientists actually resolves itself principally into an acute shortage of qualified technicians in engineering and science.

2. It revealed and emphasized the fact that the nation needs not more and bigger engineering schools, but better ones, supported by a full development and co-ordination of "The Technical Institute Idea in Higher Education." This happens to parallel and support the general tenor of the findings of the recent ASEE study and evaluation of engineering education.[2]

3. Brought again to light—and on a nation-wide basis—the facts implicit in the Wickenden-Spahr report of thirty years ago: That higher education is missing a bet in service to the nation and in service to the nation's youth by continuing failure to recognize that technical institute education is an integral part of the expanding needs for engineering education, and cannot be excised or ostracised without critical damage to all parties concerned.

4. Revealed the fact that industry across the nation, without quibbling about nomenclature or ivy-covered traditions, was—and is—of necessity meeting the "crash" needs of expanding science and technology for technical manpower by the direct mass recruitment of likely warm bodies from all possible sources including high school undergraduates. These raw recruits are given quickie injections of educational insulin to convert their latent technological sugars, and costly on-the-job learning-by-doing-and-spoiling to develop a spot-competence of sorts—and all on a cost-plus basis.

5. Revealed that an appalling proportion of graduates in engineering and science were—and still are—continuing to be occupied with work which has evolved out of engineering science into engineering technology, and which therefore properly could be done even better by graduate engineering technicians. This has been reliably reported to be as high as 75% of the manpower in some engineering departments. Here, indeed, lies a major key to the so-called shortage of engineers and scientists.

Some Significant Trends

Another facet of this technological manpower problem, and one which gives an air of finality to the situation regard-

[1] *The Technical Institute in America*, McGraw-Hill Book Company, Inc., December, 1959.

[2] "Report on Evaluation of Engineering Education," ASEE, June, 1955.

less of semantics, is revealed by data from the U. S. Bureau of Labor Statistics and from the U. S. Office of Education. These data reveal conclusively that, in spite of our much-talked-about exploding population, not enough persons are being born daily to meet the expanding need for scientists and engineers if we continue to insist upon subjecting these oncoming generations to the traditional national pattern of education, and if we continue to utilize the product of that educational system as we have utilized it up to this time. The rate of increase in need for technological manpower greatly exceeds the rate of increase in the national population.[3] The change is upon us, and it is no passing storm. The time already is past due for a major modification of our traditional national concepts of what constitutes an adequate educational pattern, and in our traditional concepts of what constitutes a balanced utilization of manpower. The change is inevitable. The only real choice that we have is whether we will effect the change through thoughtful planning and orderly processes of action, or just doggedly stand by our outmoded concepts and suffer the inevitable change through the force of circumstances with its resulting dislocations and waste.

Another significant index in the manpower situation is the progressive decline in recent years in the total number of freshmen entering engineering colleges. This means fewer engineers and scientists to be graduated, instead of more as is called for on the present basis of utilization. Even if one takes the total enrollment statistics for both science and engineering, the projected curve in terms of graduates fails very substantially to meet the curve of expanding requirements on the basis of traditional utilization. Here, again, a major change of concept is indicated in both the educational pattern and the utilization pattern. There has been much discussion and speculation about this phenomenon. Suspecting that the technical institutes might have been sequestering the students who failed to register in engineering schools last fall, for the second successive year, the Manpower Commission of The Engineers Joint Council circulated an emergency questionnaire to all accredited technical institutes. The questionnaire results showed that freshman registration in recognized technical institute curricula also was lagging behind where it logically should have been.

This latter situation reflects one of the major problems which continues to arise to plague the technical institute idea in higher education. That is, the question of status—social status, if you please. This status question is inherent in the prevailing American habit of regarding a four-year baccalaureate degree more as a mark of social distinction than as a measure of the fitness and effectiveness of the educational program for the individual receiving it. This traditional over-emphasis on the collegiate baccalaureate program has by direct inference and popular understanding placed the brand of second-class status on the two-year technical institute program. This situation has been condoned, if not actually promoted, by the four-year colleges and universities, including the engineering colleges with minor exceptions and some recent converts. Now, it is up to the engineering college, and to engineering education in general, to pitch in and help correct this unfortunate and all-too-common public misconception of the proper status of the technical institute program in higher education. The true measure of value of any educational program, from kindergarten to graduate level inclusive, is the effectiveness of its service to the individual in the development of his personal talents, rather than in any black magic associated with some measure of calendar time. This, then, becomes a logical basis for status, if we must have status—and it would recognize all equally effective programs as meriting equal status.

Let us turn now to a brief discussion of the engineering technician and his logical place in the technological manpower picture.

[3] "Engineering Manpower and the National Interest," The Engineering Manpower Commission of Engineers Joint Council. January, 1960.

The Place of the Engineering Technician

The place of the engineering technician is as broad and varied as the field of engineering itself. In fact, the place of the qualified technician is well established—and growing—across the whole spectrum of professional, technical, and business enterprise. It is neither new, nor peculiar to engineering, although engineering has been particularly slow in recognizing it.

Just as a large and growing segment of the engineering science of yesterday has become today's technology, and as such is competently handled by qualified engineering technicians, so will much of today's expanding science become tomorrow's technology. As the frontiers of engineering science move on, there must be an ever-growing supply of competent manpower to keep the over-all engineering enterprise operating and growing. Recognition of "The Technical Institute Idea in Higher Education" provides a logical channel for the expansion of total technological manpower without any "watering-down" or "down-grading."

The quantitative aspects of this situation may be indicated by the fact that in the present national economy there is a confirmed need for qualified and properly prepared technicians in engineering and related technologies which numerically exceeds the much-talked-about need for scientists and engineers. From this fact it follows that one of the most productive ways to increase the effective total supply of engineering-scientific manpower is to co-ordinate the development and utilization of the engineering technician with the development and utilization of the engineer. This presumes the courage to turn over to the engineering technician those segments of yesterday's engineering and science which have become today's technologies. And it must be recognized that these are very large segments. By doing this methodically and determinedly, a corresponding multiplication of the time and energies of available qualified engineering-scientific manpower would be accomplished.

The Engineering Team

Much has been said about "The Engineering Team." Let us examine it briefly. The phrase represents a convenient word-picture which not only reflects the approach to modern technological problems which is required by their magnitude and complexity, but which helps to visualize the working relationships involved. In the beginning, when engineering was more art than science, the function of the engineering technician was not clearly separate from the function of the engineer. One person performed, and as we already have said, in too many cases still performs both functions. Failure to recognize this fact not only has interfered with full recognition of the separate but intimately related functions, but also has allowed considerable inefficiency in utilization of manpower to take hold in today's industrial world.

It is instructive to consider why and how technical-institute education came into being apparently so long before the need for it began to be appreciated.[4] Reflection upon this paradox brings to mind the claim of some engineers that engineering is one of the older professions, or at least occupations of mankind. According to this view, the first engineer was the man—or woman—who first supplemented his own bare-handed activity with some kind of instrument or tool that employed or made use of the forces or materials of nature. What seldom is fully recognized is that this same person was in effect a one-man "engineering team"—the engineer who had the inspiration to conceive and the imagination to apply knowledge or intuition, the engineering technician who completed the practical application and the craftsman who made or used the tool.

In thus referring briefly to the one-man engineering team of history, we cer-

[4] Although the technical institute has grown out of the American culture and economy, the idea of the technical institute as it is known today was introduced into the U. S. educational pattern by Frederick Pratt in Brooklyn, New York, in 1895 as a direct adaptation of the German Technikum.

tainly do not imply that the one-man team was or should have been conscious of the separate technical roles which he performed. The three-part concept of the engineering team is the end result of a 200-year evolution in the human mind. The necessary basis for this concept was the incorporation of more science into engineering. In turn, modern science can claim but a few centuries of existence as a body of knowledge since it began only after a careful observation of nature was coupled with mathematics to produce the inductive, scientific method. Thus the three-part engineering team could not logically have been recognized more than a half-century ago—and then only by a person possessed of the extraordinary vision to foresee that the experiments of Galileo, so hotly disputed by contemporary scientific "authorities," would provide within a few hundred years a scientific base under the activities of the builders of history, and thus introduced to the world the phenomenon of modern engineering.

It took the catastrophic events of World War II to abbreviate the slowly narrowing time-lag between discoveries in basic science and their application in engineering. As the engineer has become acutely aware of his relationship with the basic scientist, he similarly now has before him the conditions that demand his relationship with the engineering technician. Survey findings, however, indicate that neither the engineer nor the engineering educator has yet fully and generally perceived—or been willing to recognize this relationship.

Fifty years ago the scope of available technological and scientific information was of such proportions that traditional four-year engineering curricula had a fair chance to cover the ground reasonably well. With continuing expansion of scientific knowledge, and growing realization of the new knowledge still to be learned or digested for later application, the engineering spectrum—educationally as well as professionally—must be *re*-evaluated and *re*-divided. This is where the engineering technician comes into the picture.

Technical Institute Philosophy

Having briefly discussed the engineering technician, let us consider briefly the relationship and philosophy involved in the educational program best suited to his development. I cannot too strongly emphasize the critical necessity of approaching the whole matter of technical-institute education as a philosophy rather than as an institution.

The basic objective of "The Technical Institute Idea in Higher Education" is the development of qualified engineering technicians proficient in a preselected field of technology. In general, the technical-institute program is designed to accomplish its objective within two academic years. Usually the associate degree is awarded for completion of such a program.

In the sometimes confusing parlance of educators, the technical-institute program therefore is commonly referred to as a "terminal" program. This causes many qualified people to shy away from it, mistakenly. The technical-institute program is no more "terminal" than any other collegiate degree program. It is "terminal" only in that it is not specifically designed to meet the limiting requirements characteristic of most college and university catalogs for "transfer credits" from preparatory schools. The bonafide technical-institute program is designed instead to give the student a high degree of proficiency in his selected field of technology, solidly supported by a sound working knowledge of the mathematics, basic science, communication skills, and technological principles involved in that field. The emphasis is upon the understanding and application of fundamental principles rather than upon their theoretical development. Increasing attention is being given to the human relationships involved.

The fundamental philosophy of "The Technical Institute Idea in Higher Education" is that for every young person who has the capacity and incentive to pursue formal technological education through to the academic heights and professional frontiers represented by bac-

calaureate and advanced collegiate degrees, there are many young persons who have the capacity, interest, and aptitude to develop productive and rewarding careers in the expanding realm of applied science and the technologies which neither require nor justify as many as four or more years of collegiate study.

Contrary to the human tendency to define things in terms of limits and boundaries, it seems necessary and desirable to consider definitions of the engineering technician and of the technical institute educational program in terms of what we might call "center-line co-ordinates" rather than "boundary limits." In other words, the definition of the engineering technician, to the extent to which it is specific and limiting, applies to the starting point in his professional career rather than to the finishing point. The ultimate to which any individual may progress is limited only by the personal interest and talents of the individual and the effort which he makes to enhance them.

The Technical Institute Idea in Higher Education

Technical institute education must be recognized as being one of the areas of the total field of engineering education. Thus it is eligible for and needful of appropriate attention in order to accomplish a desirable integration of the total overall space-age pattern of engineering-technological education. This concept makes a multiple-dimensional field (that is, one with emphasis on an application orientation such as the technical institute program) just as appropriate and necessary as one with emphasis selectively on areas of subject-matter orientation.[5]

We must always remember that the function of formal education is preparational, not restrictive; that it is the provision of an accelerated take-off for the individual, putting to use the accumulated experience of his predecessors, rather than an entry into a mutually exclusive area. In other words, the route to the top, in continuance of the fundamental American tradition, must always be open around as well as through formal curricular classroom instruction. The various state registration laws reflect this basic concept. There is no ceiling on the ultimate accomplishments of anyone, such as the engineering technician, except his own talents, opportunities, and initiative.

One clear difference between the technical-institute program and the vocational-technical program long recognized in both federal and state legislation which has primary relationship toward the area of the secondary school, lies in the contrast in basic orientation of the two programs: (1) The basic objective of the technical institute program is to turn out competent engineering technicians capable of productive service and growth in and with the selected field of engineering technology. This presupposes rigorous screening and selection of entering students to assure appropriateness of aptitude and interest. (2) The basic objective of the vocational-technical program is to accept students as they come along, and to help them make the best use of their talents at whatever level these happen to materialize. Both these programs are important contributions to society and to their respective participants, *but* they are distinctly different in philosophy and neither can take the place of the other. In the ability to see the inter-relationships of these two educational approaches, and the courage to operate accordingly, lies a great challenge to education in general and to engineering and technological education in particular.[6]

For example, these and other important distinctions are critically and regrettably confused in Public Law 85–864, the hastily-contrived "National Defense Education Act of 1958" which grew out of the Sputnik hysteria. Under this law vast sums of public tax money are to be funnelled out ostensibly for what is understood to be technical institute education, but which actually is specifically

[5] "Evaluation of Engineering Education," p. 5.

[6] "Evaluation of Engineering Education," p. 11.

(*Continued on page 63*)

The Future Engineering Needs of Large Industry

S. W. HERWALD

Vice President for Research
Westinghouse Electric Corporation

The function of an engineer is to apply science to the economic filling of human needs.

Industry needs—now, and in the future—more informed and creative young men who believe this function is important enough to be their life's work. Engineering schools must re-emphasize the importance of the engineering function and organize their curricula to attract and educate the type of men required for the rapid exploitation of the new technology flowing out of research.

To orient the discussion of engineering education requirements, it is instructive to review the four phases of an engineer's responsibility that are implied by the previous definition of his function. These are:

1) *Perception* of a human need—present or future.
2) *Definition* of the need in terms that will permit translation of the need into technical and economic terms.
3) *Application* of available technology to obtain a workable and economically acceptable solution.
4) *Communication.*

Taken as a whole, these responsibilities define the engineering approach. It must be a "total-problem" approach. The engineer who is interested only in the scientific niceties of a development, design or application problem can only do part of the real engineering job.

In order to produce an engineer who is oriented toward the "total problem," engineering schools must develop the student's abilities in each of these areas.

Second in a series recommended by the Relations with Industry Division of ASEE.

Perception and Definition of Needs

Today's industrial situation demands a great deal more of an engineer than the ability to solve a problem, once presented. Rapid obsolescence of product lines and highly competitive markets require creative searches for new opportunities for exploitation. We need *bold, new definitions of problems* to stimulate the flow of bold new approaches to their solution.

Traditionally, engineering schools have concentrated on problem solving rather than upon problem identification and definition. This was a natural tendency: courses in problem solving are easier to teach than courses which attempt to develop and mature the engineering student's ability to think.

Training programs in industry suffer from the same deficiency—and for the same reason.

In years past, the engineer's initial deficiencies in the area of problem identification and definition were slowly but surely corrected as he gained experience in his chosen specialty. After 5, 10 or 20 years he had achieved sufficient maturity to be able to distinguish the important from the unimportant.

Today—and in the future—we do not have the time for this leisurely process. The life cycle of a field of specialty may not last more than 10 years as has been the case for much of the engineering art in the guided missile field. In this situation, the engineer who is insensitive to changes in the basic nature of his problems is worthless, regardless of his problem-solving ingenuity.

Engineering colleges and industry

S. W. Herwald did his undergraduate work at the Case School of Applied Science, where he received the B.S.M.E. degree in 1938. He earned the M.S.M.E. and Ph.D. degrees from the University of Pittsburgh, receiving the latter in 1944. He began his career with the Westinghouse Electric Corporation in 1939 as central engineer at East Pittsburgh, with emphasis on servomechanism development. He has remained with Westinghouse and is now Vice President for Research. He has written numerous technical articles on servomechanisms, feedback control systems, and analog computers, and holds several patents on control systems. He is a Fellow of the Institute of Radio Engineers and member of several other professional organizations.

must develop a workable approach to providing the young engineer with the necessary training and mental discipline for performing the problem identification and definition function. New ideas are urgently needed.

Application of Available Technology

The amount of scientific information available to engineers for the solutions of problems doubles every fifteen years. Engineering schools are making a valiant effort to keep their curricula abreast of this technology explosion and in some cases, these efforts have met with marked success. Industry has come to depend upon recent graduates as a primary source of the new technology. This is placing a high premium on the graduates from schools that have done the best job of modernizing their programs.

In general, the larger schools are leading the way toward the adoption of new teaching methods and the introduction of new material. Such modifications are expensive and time-consuming; the smaller schools are, therefore, handicapped. It is anticipated that during the 1960's we will see an increasing tendency for the large universities and industry to set up mutual aid programs with the smaller universities for the purpose of speeding-up the modernization of our entire engineering education plant. Such actions are very necessary because the engineering manpower requirements of the future will tax all our present and planned facilities.

Communication

The results of an engineer's work have neither meaning nor usefulness unless they can be communicated to other engineers and—more importantly—to people in the manufacturing, marketing and customer organizations. The engineer's inability to communicate is classic. It is also tragic in an age where technology is a dominant factor of national survival and industrial health. The "snow-job" artist and the men who cannot extract ideas from technical detail do not and cannot make a significant contribution. The engineer must be taught the importance of reducing complex technical matters to a form that can serve as an intelligent basis for management decision.

He must also be taught the mechanics of adequate written and verbal expression. Because these skills are difficult to acquire, something more effective than a two-hour course in "Engineering Reports" will be required. Once again, new ideas and intelligent experimentation are urgently needed.

Liberal Education and the Engineering Profession

HERBERT MILLER

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This inquiry is similar to other investigations of the extent of liberal education in the engineering professions in that it is concerned with the amount of time given to liberal, semi-professional and professional areas in the curriculum. It differs in three major ways: (1) It is part of an over-all survey of persistent trends in a variety of professional education programs conducted by the Institute of Higher Education under the direction of Dr. Earl McGrath. (2) Special attention has been directed to the formulation of three broad divisions of the curriculum, and this report will include an analysis and rationale for this classification system. (3) The study has involved 30 engineering schools and 178 curricula, the data on which are presented graphically. The results of this analysis have been compared with a composite of the goals stated by schools in their catalogs, as well as those reported by engineering societies.

For the past ten years the efforts of the engineering societies, The Engineers' Council for Professional Development, and the American Society for Engineering Education have been directed toward the extension of a broad social and humanistic education for engineers. This goal rests on the assumption that the exigencies of society must be met by *educated* men who have been trained not only to perform tasks but "led forth" to understand their meaning in human terms.

The present peril in the Sputnik age and a reaction against curriculum inertia are both instrumental in shaping the dimensions of efforts to reinstate a considerable component of liberal arts education in the engineering schools. The Hammond report casts the shadow of the present as well as the silhouette of the past. It has become a truism to state that citizenship demands a broad understanding often not possessed by the specialist. The responsibility of understanding the human implications of his endeavors demands an intelligent appreciation of the humanities and the social sciences often neglected in the training of the practical man. As society becomes more complex and more fragmented, the necessity to see life as a whole, integratively and meaningfully, becomes more urgent. This purpose cannot be achieved by greater specialization. This theme is reiterated by professional engineering organizations and is echoed in the catalogs of engineering schools. A recent study of general education as a part of the total education of the engineer, for example, states that

> . . . many of the ablest men in the humane and social disciplines are deeply perturbed by the critical problems the human race is facing. They may feel that our technology has outrun our mastery of the social skills, and that unless the full impact of our humane and social knowledge is brought to bear on the scientific and technological leadership of our civilization, civilization itself is doomed.[1]

Since 1917 there have been many studies of the role of the liberal arts in engineering schools. The present investigation by the Institute of Higher Education concerning current themes and trends in engineering education is related to and is, in a sense, an extension of four of the many important appraisals of the past forty years.

Edwin Holstein, writing in the May, 1958, issue of the *Journal of Higher Education*, has neatly summarized the results

[1] *General Education in Engineering*, ASEE, p. 39.

of these inquiries. Holstein observes that in 1917, Charles R. Mann,[2] reporting for the Society for the Promotion of Engineering Education (now ASEE), showed that since the Civil War the liberal education part of engineering curricula shrank from 27% to 19% in terms of time given to these subjects; even science and mathematics dropped from 32% to 29%.

W. E. Wickenden[3] in 1930 estimated that the corresponding trends between 1870 and 1923 were: professional subjects increased from 35.7% to 53.5% of the total; semi-professional courses fell from 35.5% to 30.5% and liberal arts subjects from 28.8% to 16%.

Richard H. Rowntree[4] of Ohio State University observed the same general trends in 1941.

The latest study[5] of the curriculum content of 112 mechanical engineering programs completed in 1954 showed the national average of the liberal content of engineering programs to be 17.8%; semi-professional subject matter 26.2% and professional, 56%.

In making the present analysis the Institute was concerned not only with a further study of the trends apparent in the earlier investigations, but a primary purpose was to set up categories which would more sharply delineate the often-nebulous boundaries of the practical and the academic. Such a delineation has made it possible to pinpoint more accurately the actual dimensions of change in engineering curricula.

[2] Charles R. Mann, "Report of Joint Committee on Engineering Education," *Proceedings of the Society for the Promotion of Engineering Education* (SPEE), Vol. XXV (1917) pp. 198–205.

[3] W. E. Wickenden, Director of Investigations. "A Study of Evolutionary Trends in Engineering Curricula," *Report of the Investigation of Engineering Education* 1923–1929, SPEE. Vol. I (1930).

[4] Richard H. Rowntree, "The Present Status of 'Non-technical' Engineering Education in American Universities," *Journal of Engineering Education,* Vol. XXXII (Nov., 1941) pp. 215–223.

[5] Jennings B. Sanders, *General and Liberal Education Content of Professional Curricula,* 1954.

The five categories into which the curriculum has been divided in the chart have been selected on the following basis: Electives have been considered in a separate category because to some extent they are an unknown quantity. ROTC, which in some cases is a significant piece of the academic pie, has been isolated on the grounds that it can not be classed with liberal subjects and is professional only for those students who expect to make a career of military life. The significance of this factor is revealed in the report for 1956 of the American Society for Engineering Education, which stated that probably the greatest single obstacle to the establishment for all engineering students of a substantial core of study in the humanities and social sciences is the advanced ROTC program. The report stressed the point that ROTC credit should be substituted for work in neither the humanistic-social nor the scientific-technical stems.

The category of liberal as distinct from semi-professional and professional includes the area of the humanities and *some* of the social sciences. Human relations courses, for example, oriented to the practical concerns of business rather than toward the aims of general education are excluded from the liberal education grouping. Justification for this classification is drawn from several reports of professional organizations. The following statements from a report of a committee on the aims and scope of engineering education show the rationale for this system of classification:

The humanistic-social studies should be directed toward:

1. Understanding of the evolution of the social organization within which we live and of the influence of science and engineering in its development.

2. Ability to recognize and to make actual analysis of a problem involving social and economic elements, to arrive at an intelligent opinion about it, and to read with discrimination and purpose towards these ends.

3. Ability to organize thoughts logically and to express them lucidly and convincingly in oral and written English.

4. Acquaintance with some of the great masterpieces of literature and in understand-

ing of their setting in and influence upon civilization.

5. Development of moral, ethical and social concepts essential to a satisfying personal philosophy, to a career consistent with the public welfare and to a sound professional attitude.

6. Attainment of an interest and pleasure in these pursuits and thus of an inspiration to continual study.[6]

A later committee report said concerning the line between the liberal and the semi-professional:

> The seeking for immediate usefulness in the social studies and humanities as tool subjects in engineering may well lead to failure to achieve the objectives set forth above. Such courses as accounting, industrial psychology, investment, economics, comparative costs or city management may be just as technical as engineering studies. It is outside of such fields that the social-humanistic studies must lead the student.[7]

Or again:

> Humanistic studies must be distinguished from business training.[8]

Thus, certain of the reports of the professional organizations concerning the boundary lines between the liberal, semi-professional and professional categories supply the basis for the classification scheme used in this study. Following this scheme, those subjects which are clearly liberal are so labelled. Those subjects which do not lie directly within the province of the engineer but which are task-oriented and fit within the scope of the engineering profession as an instrumental aid to the pursuit of a vocation are termed semi-professional. For example, chemistry, mathematics and physics, while broadening and non-instrumental to the journalist, historian or fine arts major, are indispensable tools for the engineer and can hardly be termed "liberal" in the same sense as are courses in literature or world history. Yet these sciences are not so narrowly specialized as are kinematics or statics or methods in the practical manipulation of gears and pulleys in the engineering laboratory. The sciences, tugging in both directions, along with business and utilitarian social science courses, are relegated to the middle zone of the semi-professional.

[6] "Report of the Committee on Aims and Scope of Engineering Curricula." SPEE, March, 1940.

[7] "Summary of preliminary Report, Committee on Evaluation of Engineering Education," *Journal of Engineering Education*, Vol. 44 (Nov., 1953) pp. 144–145.

[8] *General Education in Engineering.*

Findings

On the basis of this system it is possible to proceed directly to a consideration of the tabular representation of the curricular components of 30 representative schools of engineering.

The Mean Per Cent of the Liberal Category

Considering only the liberal component, the average of 13.4% is lower than the SPEE's estimation of a national average of 17% and the Hammond recommendation of 20%. Curriculum analysis is subject to statistical error; it is difficult to compute such error within minute gradations; the distinction between a numerical difference and a true statistical one when dealing with variations of 3 or 4% is not established. The slight decline, in these terms, in the proportion of science and mathematics noted by both Mann and Wickenden may be not statistically significant. The average per cent of the liberal component that is established in this study may well be within the range of the national average, which is not fixed rigidly at 17%. It is, however, obvious that it does fall short of the expressed ideal of the ECPD.

Proportions between ROTC and the Liberal Category

As will be indicated in our comparison of goals and practices, many schools state they are interested in producing citizens; not one states that it is interested in producing soldiers. The chart indicates that some schools give almost as much time to ROTC as for the sequence of liberal studies. It seems appropriate to infer that in actual operation, though not in the statements of objectives, many engineers are influenced as strongly by the military as they are by the liberal elements of their programs.

REPRESENTATIVE[a] SCHOOLS OF ENGINEERING

PER CENT OF TOTAL CURRICULUM DEVOTED TO VARIOUS COMPONENTS

School of Engineering	Per Cent of Total Curriculum			Electives	Miscel.[b]
	Liberal	Semi-Professional	Professional		
A	22	31	38	—	9
B	17	34	38	6	5
C	8	50	39	—	4
D	8	28	50	15	—
E	12	29	46	8	5
F	5	32	43	14	7
G	7	30	51	8	5
H	12	32	40	8	8
I	17	31	38	10	5
J	4	33	47	10	6
K	13	32	52	—	3
L	11	35	45	5	5
M	17	29	44	—	11
N	13	27	48	6	6
O	6	50	39	1	4
P	18	30	34	9	8
Q	6	35	51	4	4
R	19	32	49	—	—
S	19	29	49	3	—
T	20	30	48	2	—
U	8	30	41	12	8
V	18	34	44	—	5
W	20	25	51	—	4
X	19	33	41	4	3
Y	14	31	44	8	3
Z	16	36	44	1	3
AA	8	27	57	8	—
BB	16	29	47	1	7
CC	14	30	51	2	3
DD	15	28	45	13	—
Mean Per Cent	13.4	32.1	45.1	5.3	4.4
Per Cent Range	4–22	25–50	34–57	0–15	0–11

[a] The schools whose curricula are assessed here were selected from among all accredited schools of engineering in the United States, according to whether they were public or private, university affiliated or independent, secular or religious and according to geographical location. The sample is in proportion of one to five with respect to the total number of schools accredited by the Engineers' Council for Professional Development.

[b] In this column is recorded percent of curriculum devoted to such courses as physical education and military training. Some colleges listed no requirements in these areas.

Deviations from 100% in the total percentages of the five categories result from rounding errors incurred in averaging various curricula within Engineering Schools.

The Wide Per Cent Range

Examination of the chart will show that there is a wide variation in curricula among these schools. Although logic might dictate that a profession such as engineering, which is bound together by professional concern and by fairly uniform agreement on standards, values, purposes and techniques, should also be similar in the pattern of its education, the chart reveals a pattern of unity but within considerable diversity.

Analysis of Goals

A vital part of this research is found in a comparison of the expressed goals of

the institutions with their actual curricular arrangements.

Statements concerning professional and academic goals have been selected from the catalogs of the 30 representative institutions listed in the chart. Footnotes have been eliminated, as it seems needless pedantry to itemize this sort of raw data.

Underlying themes in the statements of goals are: professional competency in engineering practices and principles; preparation for future growth; social understanding; citizenship; civic and professional leadership; a broad general background. In the terms stated by one university, there is an attempt to produce, "top-flight engineers; top-flight citizens."

Variations on these themes, or special emphases on some of them, indicate the operation of particular interests. One school calls attention to the fact that "the rapid development of our state and the whole Northwest has resulted in a demand for the most skilled and the best trained engineering and industrial leaders," while another is concerned with the student being a "gentleman of Christian culture."

Other variations reflect the gamut of assorted educational philosophies and a host of varying epistemological assumptions on which these programs rest. Some colleges make explicit a distinction between education and training, while in others the student is expected to get a well rounded *training* in the basic sciences and in English.

The dominating goals of most of the schools have a practical complexion. Knowledge related to a career is emphasized, and seldom can the more traditional aim of culture for its own sake be observed. The Catholic universities which stress the "education of the whole man" and the "harmonious development of the various faculties" of the student constitute exceptions to this general situation. Another striking deviation is to be found in the catalog of a well-known school, where it is stated that the integrative program tends towards "developing powers of judgment and taste." Judgment is a word that appears often as a goal, but *taste* is a rarity.

Many institutional statements fail to distinguish between the liberal and the semi-professional components of a curriculum. As has been noted, the ECPD has argued strongly for this distinction. One institution believes that the "professional training of an engineer (should) include at least an acquaintance with the humanities in order that scientific discoveries and developments by engineers may result in the real advancement of man. To help the young engineer achieve his purpose in life, the university offers, in addition to the prescribed engineering subjects, a wide selection of courses in the Arts and Science and Business Administration."

The above statements of goals are by no means exhaustive of the dimensions of engineering education, but they do serve to show the main aspects of their expression in the catalogs of these, and doubtless other engineering schools.

Some Conclusions

Some conclusions can clearly be inferred from the findings in this study. One is that there is not necessarily any relationship between the proportionate emphasis placed upon liberal, semi-professional or professional aims in published literature and actual curricular practices. The stressed goals of the institution are often at odds with its actual day by day practices. There is conclusive evidence that this situation prevails in professional education other than engineering. Paradoxically a greater proportionate space is taken up in catalogs with expressions of liberal aims than is reflected in the actual curriculum. For example, while 45.1% of the curriculum may be devoted to professional study, far less than 45% of the statements describing the entire range of goals is devoted to professional aims and far more than 13.4% of catalog space is devoted to choric expressions of liberal objectives. Great emphasis is placed upon citizenship and ethics, and considerable attention is paid to creating attitudes favorable to a socially approved environment which conforms to the contemporary ex-

pectations, but the curriculum does not always reveal how these goals are to be achieved. Perhaps this is the tendency noted by the sociologist, Bierstedt, who said that: "Each society regards its central ideologies as sacred and tolerates no skepticism with respect to them. Indeed, it is a significant sociological fact that the pressure to believe them is frequently stronger than the pressure to conform to the norms of conduct to which they are related." [10]

As indicated in the following statement, there is a tendency to expect too much in the way of educational results for the limited time devoted to liberal studies:

> Implied in some of the glowing statements the committee has examined is a faith that a few courses in the humanities and social sciences can provide health and emotional adjustment, personal and civic success, clarity of thought, moral integrity, civic responsibility, aesthetic sensitivity, professional vision and in general a kind of serenity and wisdom we had thought was reserved for Providence alone. The objectives which some schools profess to accomplish in courses involving twenty-one to twenty-four semester hours would appear to rival or even to outstrip, what might be expected from a full four year liberal arts program. The committee doubts that grandiose statements of good intention serve any very useful educational purpose. On the contrary they are likely to lead either into self-deception or into frustration and disillusionment.[11]

There is a tendency to label courses "general education" which appear to be oriented to immediate practical purposes and which seem to have been included in the curriculum to serve professional rather than liberal aims. It may be that this tendency gives testimony to disagreement over or lack of understanding of the liberal components of education. The report of the American Society for Engineering Education that was cited earlier notes that the social sciences, particularly economics, are attractive to colleges because they seem to be both liberal and practical.

In other cases there may be fundamental disagreement on the nature of general education. One school, for instance, states that it includes "a program of general education to achieve a better understanding of our natural world." The program, in common with that of most of the schools in this study, centers on chemistry and physics and gives virtually no attention at all to biology. Surely the term "natural world" must include the world of the biologist as well as the world of the physicist.

The more quantitative aspects of the recommendations of the professional organizations seem to be the ones preferred for implementation. Although this study indicates that individual institutions often fail to see a dynamic relationship between goals and practices, there is a continuing concern in the engineering profession to incorporate liberal education in professional training and to close the gap between ideal and reality. If, however, the commonly asserted aims of the leaders of the profession of engineering, and the liberal practices of a few well-known institutions are to be realized generally, substantially more attention will have to be given to education in the social sciences and the humanities.

[10] Robert Bierstedt, *The Social Order*. p. 151.

[11] *General Education in Engineering*. p. 5.

ALL MEMBERS PLEASE RESPOND

All members of the American Society for Engineering Education were sent a Directory Data card during the month of September. **This year it is essential that all members of the Society fill out these cards and return them to the office of the Secretary.** The Yearbook-Directory is being revised and every member must have sent in one of these cards to be fully and accurately listed in the next issue. Members who have not received a card should notify W. Leighton Collins, Secretary, ASEE, University of Illinois, Urbana, Illinois.

Simulators for Industrial Engineering Undergraduate Laboratories

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One of the real problems faced by the instructor in the motion and time study laboratory is the lack of available subjects upon which the students may practice the use of the tools they are to master. This need is more sharply felt in the case of such industrial engineering tools as the man-machine chart and the assembly process chart which in practice are used in the study of relatively large and expensive automatic equipment or large scale processes. In many such cases, it is not feasible to take the students from the laboratory to a real operation of such a machine or process because of the lack in the college community of an available industrial operation of the type needed, because of the time loss from the students' carefully controlled schedule, or because the beginning students' abilities are not capable of handling, within the time available, the complexity and speed of the real situation. In such cases, the usefulness or desirability of realistic and flexible training aids or simulators in preference to "paper problems" seems unquestionable. The problem is the development of such simulators within the college departments' restrictions of funds and storage space. The purpose of this paper is to consider the desired characteristics of such devices and to describe the construction and use of one such device developed by the Industrial Engineering Department at Texas A&M College for use in its basic motion and time study course.

Copies of the plans for the simulator described in this article may be obtained from the author on request.

Characteristics of a Simulator

The first requirement which must be met by the laboratory trainer is that it must faithfully represent the machine or process which it is intended to simulate in those characteristics which are of importance to the student's understanding of the use of the technique to be practiced. For example, in representing the problems of balancing a line of independent semi-automatic machines, it is desirable, almost mandatory, that some means be provided for the controlled introduction of random delay and down times in the machines of the line. On the other hand, it is not necessary or in some cases even desirable that the simulator include characteristics of the real machine or process which are not relevant to the problems with which the student is concerned. Again, with the line balance simulators, the product flowing through the line of simulators need not be a real product; pieces of paper do nicely if each different "machine" in the line only puts a distinguishable mark on it. In fact, when the requirements of cost and volume of data to be generated are considered, it probably will not be a real product, but something chosen along these lines. The important thing is that its relationship to the simulated machines in the line be the same as that of the real products to the real machines so far as the characteristics involved in the problem are concerned.

Flexibility of operation is also a very desirable characteristic. To be completely successful as a laboratory training device, the simulator must be capable of presenting different versions of the same problem. This need rises from two

sources. The most important is the need to provide the student with the stimulus of new and unsolved problems to minimize the rote use of a fixed pattern of solution. The other is to reduce the temptation to the poorer student to copy a solution handed down from previous years. This flexibility often can be achieved by including in the design of the simulator one or more variable characteristics such as cycle time.

Another feature which is desirable almost to the point of necessity in a simulator of this type is that it must be operating on a time scale sufficiently small that enough data can be generated in the two or three hours of the usual laboratory period to be statistically valid and, more importantly, be intuitively reasonable to the student. Yet at the same time, the time scale of the simulated operation must be large enough to be measured satisfactorily in the time allowed with the techniques available to the student at that stage of his development.

Finally, the simulator must meet the practical limitations of the departmental budget, storage and display space, and the need for a reasonable ease in being set-up, operated and put away. The restriction of ease of set-up and operation can be easily understood after working with such a device which required several hours of faculty time to balance the operating characteristics after any change in the setting of one characteristic. When this happens, the flexibility, while still existing in theory, is found in practice to have flown.

It has been the experience of the Industrial Engineering Department at Texas A&M College that a carefully conceived and constructed simulator is vastly superior to even the best paperwork problems and in many cases the equal or better of available "live" machines or processes.

The Moonshiner's Nightmare

A trainer which has had some success in providing the beginning student in motion and time study with controlled practice in the use of the man-machine chart is the device which the faculty calls the "bottle filling machine" and the students call the "moonshiner's nightmare." Intended to represent a group of six semi-automatic machines and constructed entirely from common steel pipe at a cost of less than fifty dollars for materials, it is a manifold fed with water by a half-inch garden hose connected to the laboratory sink tap. The manifold feeds water to the six "machines." Each machine consists of a two-way valve connecting a vertical standpipe with either the manifold or a nozzle. When the two-way valve is in one position the water from the manifold flows up into the standpipe until it reaches a float type check valve with a 1/16-inch hole drilled in the float. At this point the check valve which has been open to permit the standpipe to fill without having to combat the pressure of the trapped air closes to reduce the waste of water while the small hole permits enough water to pass to provide a signal that the standpipe is full. When the valve is in the other position, the water from the manifold is cut off, but the water in the standpipe between the valve and the check valve is allowed to drain down through the nozzle in a quantity determined by the volume of the standpipe. Thus, by regulating the volume of the standpipe (by partially filling it with glass marbles), the machine can be set up to deliver a fixed quantity of water by pulling the valve handle down and leaving it while the water drains out through the nozzle into a bottle placed under it. The time for the drain down is regulated by changing the nozzle below the two-way valve. These nozzles consist of brass plugs which have been drilled. The machine's cycle then consists of a recharge element from the time the water flows up into the standpipe until it is checked as indicated by a small leakage from the check valve, an idle time from the moment of overflow until the valve is switched to drain the water into the bottle, a machine run time while the standpipe drains into the bottle, and another idle time from the moment the standpipe is exhausted until the valve is switched to begin the recharge element and a new cycle. Typical settings for the machine are a nozzle

which will discharge sixteen ounces of water in 0.50 minutes and recharge in 0.10 minutes.

The normal procedure in the laboratory is to give the student an hourly rate for the man and for each machine. The laboratory instructor then operates one machine filling approximately fifty bottles. The students time the operation and prepare, in the laboratory, a man-machine chart of the operation which they have observed, calculate the number of machines which this operator could handle in theory, and prepare a man-machine chart for this hypothetical case. The instructor chooses two of the suggested number of machines (the two nearest the theoretical optimum on either side as determined from his set-up data) and tries to operate these numbers of machines for about fifty bottles each. The students time this process and prepare man-machine charts on the operation under these conditions. The student's laboratory report is then expected to include a comparison of their calculated cycle with the cycle as it was actually done.

The success of this simulator has led the department to develop other training simulators for line balance problems, production control problems and others. Each such replacement of paper problems with simulated operations has tended to strengthen the conviction of the basic soundness of such methods.

Candid Comments

This section is open to comments on articles in the JOURNAL or on engineering education in general. Send comments to the Editor, JOURNAL OF ENGINEERING EDUCATION, University of Illinois, Urbana, Illinois.

Computers and Structures

Professor L. D. Luck, in his June, 1960 JOURNAL article, "The Use of a Modern Computer as a Teaching Aid in Structural Analysis and Design," presents several examples intended to show the superiority of digital computers over slide rules or desk calculators.

At least one of the examples presented is open to serious question as to its illustration of electronic computer importance. The example in question is a one story, single bay rigid frame. A lateral load, P, acts at the top of one column. Professor Luck suggests that this problem be given to a class, each student being assigned a different load P to ensure independent work. Computer usage is advocated to enable the instructor to obtain the resulting 20 or 30 solutions needed to check student work.

It would seem more logical in the example cited, to make one solution (with a slide rule) for a given value of P—say one kip. All other solutions required for different lateral loads could then be obtained by simple proportion (again with a slide rule). Programming and valuable machine time would be eliminated.

I am sure that there are other examples which could better have been used to attempt to support the author's case for electronic computers.

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Research on Teaching in Engineering and Related Subjects

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The research reported is that done or published between 1956 and 1960 which has been reported to the Clearinghouse of Studies on Higher Education. Only studies dealing with undergraduate teaching are included. In addition to experiments on teaching, reference is made to curriculums and to studies dealing with the prediction of student success in such curriculums.

The 42 studies in the Clearinghouse dealing with engineering, chemistry, physics, and mathematics fall into four categories, those concerned with: (i) Problem-oriented approaches to teaching, (ii) More effective utilization of teaching resources, (iii) New principles for curricular construction, and (iv) Prediction of student performance.

In addition to these studies, the Clearinghouse has on file reports dealing with other aspects of engineering such as the supply and demand of engineering manpower, faculty recruitment, graduate study and evaluation. Since the subjects were so diverse it was decided to report only those studies that dealt with, or lay close to, the problems of instruction in engineering.

No studies have been included on the use of television or other audio-visual aids in engineering and related programs, although they constitute important developments in the utilization of teaching resources. The reason for this omission is simply that the primary concern of this paper is with pedagogical rather than technical innovations.

When a study deals with more than one of the topics mentioned above, it is reported on in each of the appropriate sections.

I. Problem-oriented Approaches to Teaching

The experiments reported on this subject deal with Socratic and problem-solving methods, with case studies, and independent study. Projects are also described in which students are encouraged to do more and presumably better thinking. The studies in question are:

1. " 'Case Studies' Increase Interest in Materials Laboratory," P. F. Brandenburg, University of Wichita, *Journal of Engineering Education*, Vol. 46, No. 7, 1956, pp. 563–64.

"The class was first divided into two groups [A & B] and problems rather than experiments were assigned to each group. Instead of reports, the students in group A were required to write a procedure to be followed by group B. The problems were [designed] . . . to [involve] the students in determining why the test was necessary and what results were needed to solve the problems properly." Each problem was planned to familiarize the student with a different phase of testing so that the scope of the course would not be changed and the student would get the requisite background knowledge even though a problem approach was used. "The above plan has been in operation for two years, and has been a source of satisfaction to all concerned. . . . The students now ask questions that show interest and comprehension of test methods. . . . Finally, the approach used here . . . need not be confined to testing, but can be used with equal success in many other laboratory courses."

2. "A Graphics Course for Science Majors," Eugene Paré, Illinois Institute of Technology, *Journal of Engineering Education*, Vol. 46, No. 9, May 1956, pp 798–801.

A new course containing less specialization in instrumental drafting of machine parts promoted better freehand graphical representations in scientific reports. The innovations in content are described. The teaching methods (i.e. problem-solving) employed conserved time, improved presentation, challenged and improved the performance of students.

3. "Thought Stimulation by Demonstration Experiments," Hosmer W. Stone, University of California, *Journal of Chemical Education*, Vol. 35, No. 7, July 1958, pp. 349–51.

The method used is that of asking questions and seeking answers by conducting experiments. "Those students who were content to memorize the material of the course for the purpose of regurgitation during examinations saw how those in a class where original thought processes were used were proceeding to obtain an education in chemistry.

". . . the technique of thought provoking questions and experimental answers can be used to stimulate original thinking in a chemistry class. Many students found pleasure in these questions and experimental answers who would otherwise have been content with the minimum of thinking involved in the 'tried and true' memory system with which they entered the course."

4. "A Study of Student Achievement as Affected by Teaching Method and Class Size," Roland H. Trathen, Rensselaer Polytechnic Institute, 1957.

Two large lectures (85 and 98 students) and 2 problem sessions replaced 4 meetings of small sections (17–23 or less). As a part of the experiment, students were asked to assume more responsibility, and Socratic and problem methods were introduced.

"Students in the experimental section, including the problem sessions, received a better score on the final examination." The very capable student did well irrespective of the method of instruction. The average student, however, did better in the experimental section. Apparently, "the capable student does well irrespective of the individual instructor to whom he is assigned. The average student's performance, however, depends in large measure on the instructor."

"The student has not suffered because of his assignment to a large experimental group. It also appears that a case can be made for exposing students, in large groups, to the most capable, sensitive and stimulating teaching that a school can afford."

5. "Two Years of Experimental Work on Various Teaching Methods and Class Sizes," Roland H. Trathen, Rensselaer Polytechnic Institute, *Journal of Engineering Education*, Vol. 50, No. 5, February 1, 1960, pp. 380–87.

This article brings up-to-date the information acquired in the preceding study. In the present study "three methods of instruction were employed: small sections, lecture-discussion, and an experimental approach to be used with large classes." Some of the innovations were two lectures and two problem sessions per week, a study aid, a series of quizzes, and a great deal of freedom given to the students.

Results were similar to the experiment reported previously in that examination scores were about equal in the experimental and control sections, the expertness of the instructor was the most important factor, and average students benefited more than superior ones from being in the experimental section.

6. "Freshman Chemistry Laboratory at the California Institute of Technology," E. H. Swift, *Journal of Chemical Education*, Vol. 35, No. 5, May 1958, pp. 248–50.

The article describes an experimental program "in which the conventional work of the first two quarters of the freshman [chemistry] laboratory [was] replaced by quantitative experiments." The work was on a more mature level than the usual freshman chemistry laboratory work

and the analysis of unknowns added interest and challenge to the course.

7. "Chemistry at Harvey Mudd College," J. A. Campbell, *Journal of Chemical Education*, Vol. 35, No. 4, April 1958, pp. 172–73.

Report describes curriculum of Harvey Mudd College, which offers only four majors: engineering, mathematics, physics, and chemistry. A main thesis used as a basis for planning is "that experiments should involve the discovery of knowledge new to the observer and not readily predicted by him." The school makes "wide use of unknowns and insist(s) as much as is feasible that each student work out his own method of attack."

8. "Teaching Techniques in the Undergraduate Organic Laboratory," Stanley J. Storfer and Ernest I. Becker, Polytechnic Institute of Brooklyn, *Journal of Chemical Education*, Vol. 36, No. 12, December 1959, pp. 614–15.

To overcome student dissatisfaction with "cook book" experiments in an organic chemistry laboratory, the experiments were modified "to introduce an element of the 'unknown' and thus to raise student interest by giving him a greater responsibility in the outcome of the experiments."

Results of this curricular change were greater "enthusiasm for and better training in organic chemistry."

9. "An Approach to Laboratory Instruction in General Chemistry," Howard Nechamkin, Pratt Institute, *Journal of Chemical Education*, Vol. 37, No. 2, Feb. 1960, pp. 96–97.

An attempt to improve the general chemistry laboratory is described. The first semester laboratory is "devoted exclusively to acquainting the students with the facilities available in the laboratory and the various end-results which may be achieved by their use." In the second semester all students, working alone or in groups, are required to do actual research by developing and solving a problem or project.

The program has met with great success. Students are enthusiastic and spend more time and effort on their projects than is required by the faculty, and the use of the library has increased.

10. "An Experimental Approach to the Teaching of Superior Students," Nicholas D. Cheronis, Brooklyn College, 1958.

Progress report on an experiment to determine how quickly superior students can progress in chemistry under a system of independent study with the instructor acting only as guide. The teacher's function and course materials are described. An evaluation of the students' work is presented and the reactions of the students are reported.

11. "An Experimental Approach to Teaching Chemistry to Superior Students," N. D. Cheronis, J. G. Sharefkin, D. M. Sharefkin, H. Jacobson and H. Stein, Brooklyn College, 1958.

The purpose of this study was to determine whether superior students with good preparation can assimilate the facts, principles, and theories of chemistry by independent study with a minimum of instructor guidance. It was found that the students were able to do this. The degree of their success is indicated. An explanation is also provided of student selection, the method used in guiding the learning process and course content. An evaluation is made of the students' work (which was surprisingly good) and of faculty reactions (which were mixed).

12. "The Inductive-Deductive Method and the Physical Science Laboratory," Arnold M. Lahti, Western Washington College of Education, *Journal of Experimental Education*, Vol. 24, No. 3, March 1956, pp. 149–63.

At the University of Minnesota in classes numbering 338 and 395 students, Lahti experimented with four methods "to see which was most effective" in developing the student's ability to use the scientific method. These methods were:

(a) The inductive-deductive or problem-solving method.

(b) The historical or research method; actually a modification of Conant's Case Study approach.
(c) The theme method in Study One, the discussion method in Study Two.
(d) Standard, descriptive or "cookbook" method.

The "*observational data* indicated that the mean scores of the inductive-deductive method were higher on all parts of all tests in Study One. . . . On the Interpretation of Data Test . . . the historical and standard methods were a close second . . . the theme method slightly lower. . . . In the Design and Experiment Test the mean scores of the inductive-deductive method appeared to be considerably higher than those of the other three methods. . . . On the Performance Test the mean score of the inductive-deductive method was higher than the mean score of the standard method." The historical and theme methods followed in this order.

"The same apparent pattern was noticeable in Study Two with one exception. The mean score of the discussion on the Performance Test was considerably below the mean scores of other methods."

When these data are analyzed for "significance," "The educational conclusion is that the teaching methods do differ significantly in their effectiveness in developing in the student the ability to use the scientific method. . . . The inductive-deductive method was successful in developing problem-solving abilities in subject matter-centered problems."

Implications

The problems with which the students were faced in the foregoing experimental courses were of the sort they will encounter as professional engineers. The solutions of these problems were reached most typically by experimentation. In the case studies reported, industrial problems were attacked. These methods increased student interest and improved their performance. They were also less demanding of the instructor's time than conventional courses.

The studies reported here confirm the findings of research on college teaching in general,[1] to wit, that "spoon-feeding," irrespective of where it is done or how it is done, is not good educational practice. Students who seek their own answers, sometimes to their own questions, not only learn more but become better learners. Furthermore problem-solving simulates the life for which the student is preparing himself.

Since the engineer in today's classroom cannot learn enough to meet all the demands that even his first job will make upon him and since he cannot be instructed in what he should do with machines that have yet to be designed—but which will certainly be a part of the world in which he eventually has to make his living—he needs to learn and to learn early how one addresses oneself to problems, particularly unanticipated problems. This is presumably the reason for the new emphasis on principles and on theory in engineering (see Section III).

The engineer is also acquiring an appreciation of his need for breadth. This is manifested first in the scientific emphasis that is creeping into engineering curriculums and second, in an emerging recognition of the importance to the engineer of the humanities (see Section III). His responsibilities in today's technological society are great and they are becoming awesome.

But even with the engineer's broadening responsibilities the emphasis has to be on quality, on the quality of his learning and hence of his teaching. Since learning and teaching is a very personal business one finds in this fact still another reason why engineering is becoming more humane.

Hesitant as have been the engineer's efforts to acquire a liberal education, he could easily be more alert to his need than the liberal arts college has been to its obligations, not only to engineering and other professional schools, but to its own students. To judge from studies of

[1] "Effectiveness in Teaching," W. R. Hatch and Ann Bennet, *New Dimensions in Higher Education*, No. 2, Division of Higher Education, U. S. Office of Education.

the impact of colleges on students [2] the liberal tradition remains more a tradition than a contagious and convincing doctrine. And this is so despite the fact that it is as practical as personal and national survival, which approach the ultimate in practicality. The sad thing about higher education today is that in the ideological conflict between East and West, American college graduates are almost as unarmed as those who have not had the benefits of such an education.

II. More Effective Utilization of Teaching Resources

In engineering education, as with all subject matters today, there has been considerable experimentation with ways of making more effective use of faculty, of materials, and of time and space.

The studies reported to the Clearinghouse on this subject are:

1. "The Program for Utilization of College Teaching Resources," School of Engineering, Lehigh University, 1956–1957.

To reduce duplication and overlap in staff, courses, and laboratories in and between the different engineering departments of the university, a series of introductory courses was introduced. By concentrating upon the common rather than upon the disparate elements in the several engineering fields and by making the courses basic and scientific rather than specialized and technical, it was hoped that more realism could be introduced into the curriculum. It was also hoped that these courses would result in greater unification of the curriculums among the ten undergraduate engineering departments. By consolidating courses of a similar nature taught in more than one department, it was hoped that students might thereby reap the benefits of a "common outlook."

While it was not the intention of the experiment to save faculty time, such savings were worked. "Sections can be combined, rostering simplified, and small classes eliminated."

Besides being an apparently effective antidote for proliferation, "There was considerable qualitative improvement in the teaching of all these experimental courses." This is in part attributed to "the interdepartmental competition engendered and the close study [given] to mak[ing] every part of the course of maximum value to each curriculum concerned."

2. "A Study of Student Achievement as Affected by Teaching Method and Class Size," Roland H. Trathen, Rensselaer Polytechnic Institute, 1957.

Two large lectures of 85 and 98 students and 2 problem sessions replaced 4 meetings of small sections with 17 and 23 students or less, or the same number of lectures (70 students) and discussions (16 students) was held but one instructor replaced several.

"Students in the experimental section (large lecture and problem sessions) received a better score on the final examination."

In a course in statics and strength of materials, classes were met in large lecture and problem or experimental sections of 85 and in small lecture-discussion sections of 16 and 20 students.

"The students in the experimental sections received better grades on the final examination."

The conclusion is that "the student has not suffered because of his assignment to a large experimental group."

3. "Two Years of Experimental Work on Various Teaching Methods and Class Sizes," Roland H. Trathen, Rensselaer Polytechnic Institute, *Journal of Engineering Education*, Vol. 50, No. 5, February 1, 1960, pp. 380–87.

This article brings up-to-date the information acquired in the preceding study. In the present study "three methods of instruction were employed: small sections, lecture-discussion, and an experimental approach to be used with large classes." Some of the innovations were two lectures and two problem sessions per week, a study aid, a series of quizzes,

[2] "The Impact of College on Students," *New Dimensions in Higher Education*, No. 4, Division of Higher Education, U. S. Office of Education (in press).

and a great deal of freedom given to the students.

Results were similar to the experiment reported previously in that examination scores were about equal in the experimental and control sections, the expertness of the instructor was the most important factor, and average students benefited more than superior ones from being in the experimental section.

4. "Teacher-Demonstrations [3] Versus Shop Activities in the Teaching of Electricity: An Experimental Comparison," John Johnston. Doctoral Dissertation. *The University of Missouri Bulletin*, Vol. 59, No. 44, Education Series 1958, No. 71, pp. 47–49.

Teacher-demonstrations proved superior to shop activities as regards the acquisition of information, the cost of teaching, and the effort required on the part of the instructor.

5. "Independent Study Programs for Freshmen," Paul H. Carnell, Albion College, *Journal of Chemical Education*, Vol. 35, No. 5, May 1958, pp. 251–53.

The report summarizes a survey of research and independent study programs for freshmen in 224 selected colleges. Examples of programs offered by some of these institutions are given.

6. "Thought Stimulation by Demonstration Experiments," Hosmer W. Stone, University of California, *Journal of Chemical Education*, Vol. 35, No. 7, July 1958, pp. 349–51.

Since the experiment was successful (see #3, Section 1) in stimulating "original thinking," causing students to do more than minimal thinking, and increasing their interest in the subject, the demonstration was shown to be an effective device. If the demonstration is less demanding upon student and faculty time than is the laboratory, there are implications in this experiment for the better utilization of both student and faculty resources.

7. "A Comparison of Two Techniques of Laboratory Instruction (Chemistry)," Bureau of Industrial Testing and Institutional Research, The University of Omaha, Fall 1956–57.

Comparison was made of the value of the conventional laboratory training in the introductory chemistry course with a lecture-demonstration method of laboratory training.

"The laboratory-demonstration method [proved to be as satisfactory as] the individual laboratory method of teaching first semester college chemistry."

8. "An Experimental Approach to the Teaching of Superior Students," Nicholas D. Cheronis, Brooklyn College, 1958.

The fact that this study was done in chemistry should be of interest not only to engineers and physical scientists but to institutions contemplating the installation of independent study programs.

Since the method employed was independent study and such study can be more economical of staff time than conventional methods, the experiment constitutes still another demonstration of the effectiveness and efficiency of this method. (See No. 10, Section 1.)

9. "An Experimental Approach to Teaching Chemistry to Superior Students," N. D. Cheronis, J. G. Sharefkin, D. M. Sharefkin, H. Jacobson and H. Stein, Brooklyn College, 1958.

Since superior students with good preparation can assimilate the facts, principles, and theories of chemistry by independent study with a minimum of instructor guidance, there are implications in this study for institutions interested in better utilization and better methods. From other studies [4] one can be reasonably confident that if independent study works for superior students, it can be

[3] The virtues of lecture-demonstration in chemistry have been examined at length, there being at least one article in each of 24 consecutive issues of the *Journal of Chemical Education*.

[4] See "Independent Study," W. R. Hatch and Ann Bennet, *New Dimensions in Higher Education*, No. 1, Division of Higher Education, U. S. Office of Education, June 1960.

made, with modifications, to work for good and even average students.

10. "Excessive Use of Graduate Assistants in Recitation and Laboratory Teaching," William E. Caldwell, Oregon State College, *Journal of Chemical Education*, Vol. 36, No. 2, February 1959, pp. 86–87.

This is a series of letters by prominent teachers. Writing independently they affirm that the use of graduate teaching assistants in chemistry has decreased the effectiveness of chemistry teaching. The reasons given are a high turnover of graduate assistants and the fact that their teaching is a secondary interest. The experience of four schools is cited; suggestions are offered.

Oregon State's examination—with other institutions—of the use of graduate teaching assistants in chemistry suggests that, for some tasks and in some cases at least, greater use cannot be safely made of such subprofessional teaching personnel to protect the time of senior faculty. The University of Kentucky (see #11) has used graduate assistants in mathematics. Although the practice was popular with the students, it is not clear that their learning was greater than when taught by senior faculty.

11. "A Lecture Study Mathematics Program," James C. Eaves, University of Kentucky, 1958.

In mathematics courses, which customarily were taught in small sections of 25–50 students, the students were met in large lectures (180). Provision was also made for supervised study in study rooms that were open 30–40 hours a week. The supervision was supplied by faculty and graduate assistants. An advantage in this practice was that "it was possible to assign the most competent faculty" to the large lectures.

"Impressionistic reports are favorable both as to the quality of the instruction and as to the effectiveness of student-faculty contacts. Students and their parents . . . were enthusiastic."

12. "Preliminary Report on (Mathematics) M101-2 Study, 1956–57, On Use of Student Assistants," Ruth Churchill and Paula John, Antioch College.

In a course in the fundamentals of mathematics (a general education course) classes were met in large lectures (70 students) and in smaller discussion sections (20–30 students). The students in the large lectures met in small, 25-student laboratories supervised by upperclassmen. Students in the small discussion sections met in 20–30-student laboratories conducted by the instructor.

"The skills and content [learned] . . . did not differ significantly [in] the two types of classes."

Implications

President John S. Stratton of the Massachusetts Institute of Technology has observed that "We can no longer be prodigal with human resources;" we must recognize "the urgent importance of developing to the fullest our available talent;" we must exert "a bolder effort to release the full creative abilities of the student." [5]

Edwin H. Land, President of the Polaroid Corporation, in his Arthur Dehon Little lecture at the Massachusetts Institute of Technology had a good deal to say about a resource that, in his opinion, is not being developed in the way it can and should be developed. "In this age, in this country, there is an opportunity for the development of man's intellectual, cultural and spiritual potentialities that has never existed before in the history of our species. I mean not simply an opportunity for greatness for a few, but an opportunity for greatness for the many."

It will not happen if institutes and engineering colleges wait "for the favorable accident" but only if they "deliberately . . . introduce the small change that will have great significance." [6] Some

[5] From introduction by President Stratton to the lecture given by Edwin H. Land (see below).

[6] "Generation of Greatness—The Idea of a University in the Age of Science," Edwin H. Land. The Ninth Annual Arthur Dehon Little Memorial Lecture, Massachusetts In-

of these "small changes" have been introduced in the experiments identified above. But if the sample reported is any indication of what engineering colleges are doing, there have not been many "small changes." And this despite the fact that the Joint Council on Engineering Education has urged a reorientation of engineering education away from stress on the quickly outmoded "tool" course, operational information, practice upon working formulas and shopwork mechanical manipulation, and toward course offerings emphasizing principles and intellectual skills. Its disposition is to treat engineering as a science rather than as a technology.

The substitution of fundamental for tool courses has—on Lehigh's experience—the practical advantage that it reduces the amount of time both student and teacher spend on busy work and improves the utilization of both of these critical resources. To the conservation of student talent and teacher time can be added better utilization of equipment.

While utilization is something that might better be played down than up it clearly has been played up in this sample. Institutions of higher education can afford to play it down, because, through happy but fortuitous circumstances, many of the new educational devices examined in this paper are held to be not only better but less demanding of a faculty's contact time with students than the old.

Utilization might better be played down because to defend requests for funds on the basis that the program is economical cheapens higher education. Higher education is a different kind of enterprise from that with which the public habitually deals. Its motive is not profit. It has, or should have, however, a transcendent concern for something the industrialist and professional man understands easily—the quality of its product. The business or professional community would have no difficulty understanding this emphasis or understanding the practical utility of a case made on this basis. But many colleges do themselves a disservice by building their case primarily around the quantitative nature of their requirements.

While it is affirmed that important things cannot be measured, they need not in this instance be ignored. It may even be that some of the elements involved in the product of higher education can be measured. If the research on the evaluation of critical and creative thinking, on personality development and values, realizes its present promise, it may be possible eventually to talk convincingly about the product. But this can be done only if colleges and universities are prepared to evaluate their product and themselves. The fact that no great enthusiasm has yet been evinced in such evaluative programs is not flattering to higher education. Here as in some other areas higher education's posture is a defensive one. Where it is least defensive—in the sciences and technologies—it is presently most successful in winning both financial and moral support. What is needed seems to be more of the same—more confidence, more competence and a well-mounted offensive of the sort indicated in the foregoing pages.

It is interesting to note that in the experiments on better utilization of teaching resources reported here, the emphasis in each instance is on quality. When courses were eliminated or combined, the saving of faculty time was a by-product of the main purpose, which was to improve the educational program. The criterion for the success of large classes was whether or not students learned as well as in small classes, not how many faculty hours were saved. Throughout these experiments the *quality* of the faculty is stressed. The use of student assistants was frowned upon in one experiment because although the teaching loads of the faculty were eased, the quality of the teaching decreased.

III. New Principles for Curriculum Construction

New principles of curriculum construction in engineering are being examined. These principles are a new emphasis upon theory and concepts in both the technical and general aspects of the en-

stitute of Technology, Cambridge, Massachusetts, May 22, 1957.

gineering curriculum and in the curriculums of related fields. In one chemistry curriculum, for example, concepts are used to divide the subject matter courses into more "natural" subdivisions which reflect, in the opinion of the department concerned, greater "intellectual integrity." Provision is also being made for greater flexibility in engineering and related curriculums to the rather obvious satisfaction of the institutions conducting the experiments.

Broader, less technical, more scientific and humanistic programs are being adopted and are winning acceptance. These broader programs are recommended particularly for gifted students who will eventually have to man research and engineering projects. The room for the electives is provided by increasing the content of required courses to the extent that more content is provided in fewer courses than was the case previously.

The Clearinghouse cites the following studies as examples of the foregoing phenomena:

1. "The Program for Utilization of College Teaching Resources," School of Engineering, Lehigh University, 1956–57.

A consequence of the Lehigh experiment was greater curricular unification which gave students the "benefits of a common outlook."

There was also on the part of students an "enhanced appreciation for a more scientific point of view in engineering education."

2. "General Education in Engineering —A Report of the Humanistic-Social Research Project," The American Society for Engineering Education, 1956.

It is recommended in this study that humanities and social sciences should be made a part of engineering education. It was found that this could be done without lowering the quality of technical education or resulting in superficial treatment. Provided in detail are the recommendations of those interviewed as to the objectives of such a development, its content, curricular arrangement, its administration, and the time devoted to it. There are appendices on representative humanistic-social sequences, courses of special interest, and sample engineering curriculums.

3. "General Education in Engineering," Report of the Humanistic-Social Project, Edwin S. Burdell, Cooper Union, *Journal of Engineering Education*, Vol. 47, No. 3, October 1956, pp. 103–05.

This is a study of the feasibility and merit of including liberal arts in engineering curriculums. Recommendations are made on the basis of data which show that such a program can succeed if it has full administrative support, is treated as an integral part of the student's education, and has the full cooperation of both the liberal arts and engineering faculties.

4. "Suggestions on How to Teach 'Engineering Sciences,'" Sheldon S. L. Chang, New York University, *Journal of Engineering Education*, Vol. 46, No. 5, January 1956, pp. 456–57.

The author presents his suggestions for a unified course in engineering sciences, which would develop deeper insight in the students and would enable them to learn "a few broadly enveloping concepts" rather than to concern themselves with numerous empirical formulas.

5. "The Unified Science Program," Stevens Institute of Technology, 1958.

This description of a new program, similar in many respects to the present engineering program, stresses unity and integration. Courses in the social-humanistic area are introduced to enlarge the horizons of students beyond those of their technical interests.

6. "The English Program as Engineering Teachers View It," Frank Kerekes, The Michigan College of Mining and Technology, *Journal of Engineering Education*, Vol. 46, No. 5, January 1956, pp. 427–33.

The need for a new English program for engineering students is pointed up on the basis of existing data including:

a survey of the writing performance of juniors and seniors; a survey of practicing engineering graduates showing that a majority considered good English valuable, so valuable, in fact, that many were continuing their study of it; an industrial survey showing per cent of working time spent writing; a supervisor survey showing poor use of English among employees. It recommends a more mature level of English instruction and the inclusion of humanities in the engineering curriculum. It also urges that writing requirements be made through all four years, and that a report preparation course be introduced in the senior year.

7. "Graduate Training Based on Undergraduate Training in Fundamentals," R. E. Purucker, Public Service Commission of Wisconsin, *Journal of Engineering Education*, Vol. 47, No. 3, November 1956, pp. 223–27.

The recommendations of the Commission based on a study of education as it affects industry are: 1. the need for enlargement of the technical institute program; 2. the need for training men with a sufficient breadth of knowledge to direct a research department; 3. training for these men in the basic sciences and engineering; 4. the introduction of an undergraduate course consistent with such training; and 5. that the reactions of persons engaged in research transmitted to such a course.

8. "The Brown Experiment in Chemical Education," Leallyn B. Clapp, Brown University, *Journal of Chemical Education*, Vol. 35, No. 4, April 1958, p. 170.

The article describes changes made since the institution of an experimental program for a degree of B.S. in Chemistry in 1948. Some of these innovations consisted of changes in the timing of certain courses and decreasing the number of courses in specified years to allow students to devote more time and effort to those that they took.

The author states: "We have not accomplished miracles by the change from the standard curriculum but we think we now arrive in five semesters at a point roughly equivalent to six standard courses. This has been done by expressing some faith in the high school chemistry course, by omitting some descriptive inorganic chemistry . . . and by taking advantage of the *initial enthusiasm* for the first course." Conclusions were drawn from a questionnaire sent to 153 graduates for the evaluation of the new curriculum.

9. "A Formal Option Plan for Undergraduate Chemical Engineering," Max S. Peters, University of Illinois, *Journal of Chemical Education*, Vol. 36, No. 2, February 1959, pp. 88–89.

The report describes a curriculum revision based on the use of two standard options: 1. engineering–for chemical engineers intending to enter industry immediately, and 2. physical science–for those who will do graduate work. A detailed comparison is made of the requirements for both options in the junior and senior years. An overview of the options is also presented. The program provides adequate training and is designed to meet the interests and requirements of both average and exceptional students.

10. "The M.I.T. Plan for Undergraduate Chemical Education," David N. Hume, *Journal of Chemical Education*, Vol. 35, No. 4, April 1958, pp. 176–77.

The revised curriculum for chemistry majors is outlined and described in some detail. The changes made are mainly in timing. Organic chemistry is introduced earlier so that the teaching of inorganic, analytical, and physical chemistry can be based on a background of 2 years of college mathematics and physics.

11. "Curriculum in Chemistry at the University of Minnesota," Z. Z. Hugus, Jr., *Journal of Chemical Education*, Vol. 35, No. 4, April 1958, pp. 171–72.

An outline is presented of the revised curriculum for chemistry majors, including 24 credits in science electives and 36 in non-scientific fields.

12. "Curriculum in Chemistry at the Pennsylvania State University," John

R. Hayes, A. Witt Hutchison, and Ralph P. Seward, *Journal of Chemical Education*, Vol. 35, No. 4, April 1958, pp. 174–76.

The article describes the revised curriculum based on the findings of a 2½ year study that sought to determine whether the curriculum would be improved by reducing the number of specific courses and increasing the number of electives. The new plan provides a foundation in the facts and principles of chemistry, but devotes more time to general education. Certain courses are altered in their timing. Two optional plans for varying degrees of concentration in chemistry are offered.

13. "The Undergraduate Chemistry Seminar: A Survey," James W. Hackett, O. P., Providence College, *Journal of Chemical Education*, Vol. 35, No. 5, May 1958, pp. 254–56.

This summary of a survey of existing practices in colleges and universities relative to undergraduate chemistry seminars describes the mechanics and varieties of seminars and gives several examples of programs, some of which broaden the students' horizons and give them greater freedom and room to experiment, and others which are merely of a practical or vocational nature.

14. "The Tufts Approach," M. Kent Wilson, Tufts University, *Journal of Chemical Education*, Vol. 35, No. 4, April 1958, pp. 167–69.

A description is given of the revised curriculum which cuts down the number of required courses. By diminishing repetitive work and regrouping material, more course content is included than in the old program. This gives freedom for electives in other fields but requires advanced chemistry courses.

15. "Chemical Concepts and the College Chemistry Curriculum," Laurence E. Strong and O. Theodor Benfey, Earlham College, *Journal of Chemical Education*, Vol. 35, No. 4, April 1958, pp. 164–67.

The article describes a plan to divide the subject matter of chemistry into sections dealing with major concepts through which chemical phenomena are understood and interrelated—aiming at "intellectual integrity" difficult to achieve under present artificial subdivisions of course work.

16. "A Special Course for Superior Students," L. Carroll King, Northwestern University, *Journal of Chemical Education*, Vol. 35, No. 5, May 1958, p. 250.

The report describes a special first year chemistry course which enabled superior students to "complete college chemistry equivalent to general chemistry and qualitative analysis during the first two quarters of the freshman year thus leaving the third quarter for a course in quantitative analysis or an elective subject."

Student achievement has been very good and "students completing the special first year course have the advantage of being able to have a flexible program of courses in mathematics and physics as well as in chemistry during their last three years of college work."

17. "Chemistry at Harvey Mudd College," J. A. Campbell, *Journal of Chemical Education*, Vol. 35, No. 4, April 1958, pp. 172–73.

Report describes curriculum of Harvey Mudd College, which offers only four majors: engineering, mathematics, physics, and chemistry. One third of the students' academic work is in each of the following areas: humanities and social studies; mathematics, physics, and chemistry; and specialized work relating to major field.

18. "Integrated Introductory Course in Physics and Chemistry," Edward L. Haenisch and Lewis S. Salter, Wabash College, *Journal of Chemical Education*, Vol. 35, No. 5, May 1958, pp. 246–47.

Because neither modern chemistry nor physics can be understood without a knowledge of the other science, a combined course was designed for non-majors. Additionally, repetition of much

material was avoided. Student reaction was favorable.

19. "Objectives, Curricula, and Results of the Cornell Engineering Physics Program," Lloyd P. Smith, AVCO Research and Advanced Development Division, 20 S. Union Street, Lawrence, Mass., *Journal of Engineering Education*, Vol. 47, No. 5, January 1957, pp. 401–09.

A program was devised to give students the best foundation for general research and advanced development work, the subject-matter consisting of "the fundamental sciences of physics, mathematics, and chemistry; the constitution of materials . . . and various subject-matter from a wide range of professional engineering fields." Throughout the senior-year curriculum, integration of the various subjects was stressed. One result of the program's operation was a constantly increasing student demand for the course, despite its being "the most rigorous technical course in the university."

". . . students acquiring the Bachelor of Engineering Physics degree have a great deal more knowledge of physics and mathematics than the four-year physics majors in the College of Arts and Sciences. This is due to the fact that they commit themselves to the program when they enter the university instead of two years later and in addition they are able to assimilate greater knowledge and technical facility because of the highly integrated nature of the more rapidly moving curriculum."

Implications

The sample assembled above appears to be a representative one. It is, however, only a part of the "flow" of research and like the iceberg provides a picture of only a part of the experimentation being done or that which needs to be done. The emphasis on theory and principle in curriculum construction is authentic. What is not revealed is the ultimate refinement of this approach to curriculum construction, namely, "conceptual integration." Nor does "integration" show to advantage in the sample. The educational advantages and the practical utility of a unified, common curriculum are not developed carefully. As with most good things, the more you have, the better; part of a year, or a year, is not enough. The "common outlook" is a desirable consequence of a unified curriculum; another is the fact that courses and the elements of courses, taught in an integrated fashion, reveal and dramatize relationships and are more easily mastered for this reason. This is one place where learning theory proves out in practice. Finally, it should be admitted that integrated courses and curriculums can be more economically taught.

Provision for greater flexibility in the engineering curriculum is achieved by reducing the number of specific courses required of students and increasing thereby the number of electives open to them. These electives are used primarily to increase the amount of the student's general knowledge, whether it be in a general or liberal arts program. The need for better training in writing is recognized in curricular revisions giving greater emphasis to English composition. In one chemistry program this amounted to twenty-four credits in science electives and thirty-six in non-scientific fields. It is now felt that no specific sequence of courses is the one and only way to achieve success in a science curriculum. What is also recommended in the technical as well as the general program is that more attention be given to theoretical aspects of the subject matters studied, that is, to principles.

Additional flexibility is achieved through better preparation and a different placement or timing of course offerings. The basic idea it to concentrate inorganic, analytical and physical chemistry in the junior-senior years so that a background of two years of college mathematics and physics can be built under them. These broadened curriculums appeal to the average and the superior student and give each the opportunity to develop fully within the limits of their capacities. Some of the revised curriculums reported were the result of studies running as long as two and one-half years and some reports are evaluative studies of the revised curriculum.

IV. The Prediction of Student Performance

The following studies deal with the validity of certain predictors, mainly various tests and grade-point averages, of success in engineering and related programs:

1. "Predicting Success in the First Year of Engineering Study," William C. Lowry and Harold S. Spraker, University of Virginia, 1959.

An investigation of the validity of various factors in predicting success during the first year of study in engineering at the University of Virginia yielded the following findings: (1) The only factor studied in high school records which was of value in predicting first year average grades was percentile rank in the graduating class. (2) Comparisons of scores made on PEA test, CEEB SAT Mathematical and Verbal with first year average grades yielded low validity coefficients. (3) Multiple correlations yielded much higher validity coefficients than did the zero-order correlations.

2. "Tests for Guidance and Counseling," Marvin D. Dunnette, Minnesota Mining and Manufacturing Company, St. Paul, Minnesota, *Journal of Engineering Education*, Vol. 46, No. 5, January 1956, pp. 434–40.

This is a report of a personnel research program designed to develop good objective guides to aid educators in accurate occupational analysis. Two tests were developed: one to identify high level engineering capacity and another to measure interests and motivation of engineers performing different functions. A need was shown for good counseling and more valid tests.

3. "An Investigation of Factors Related to Success in A First Course in Chemistry at the Pennsylvania State University," Carl W. Bordas. Doctoral Dissertation. *Penn State Review of Educational Research*, Vol. IX, No. 1, November 1957, pp. 24–25.

This study was made in order to ascertain the extent to which certain factors (e.g. age, high school chemistry laboratory, high school algebra) contribute to the success of students in a first course in chemistry.

4. "Predicting Success of Junior College Students in Introductory Chemistry," William E. Kunhart, Lionel R. Olsen, and Roger S. Gammons, Hartnell Joint Junior College, *Journal of Chemical Education*, Vol. 35, No. 8, August 1958, p. 391.

The purpose of this study was to determine the reliability of predictions of success in introductory college chemistry on the basis of high school chemistry grade, high school algebra grade, ACE Psychological Examination linguistic score, quantitative score, or total score. Data were drawn from the transcripts of 111 students in public junior college.

"High school chemistry and high school algebra were the best predictors of success in college chemistry for the group sampled. The quantitative and total scores of the ACE were of a higher predictive value than the linguistic scores." All of these variables, however, had such low positive correlations that it was deemed to be harmful to use them without considerable qualification.

5. "Predicting Failures in General Chemistry," Nelson W. Hovey and Albertine Krohn, University of Toledo, *Journal of Chemical Education*, Vol. 35, No. 10, October 1958, pp. 507–09.

The report describes the development of a pre-testing program which uses reliability data from various tests to predict failures and withdrawals in the first semester of general chemistry. It was found that if those in the low group pass a course in pre-college chemistry prior to enrollment in the regular course, the chance of failure drops.

6. "The Relationship of the ACE Scores and the Mathematics Achievement Score to Achievement in Freshman Chemistry, Research Report No. 68," DePauw University, 1956.

Study showed that achievement in mathematics bears a greater relationship to achievement in freshman chemistry than do quantitative ability, linguistic

ability or a combination of the two. Total ACE score is a better predictor of success than are either of its sub-scores.

7. "A Report on an Analysis of the Mathematics Placement Test and Explorations in Predicting the Performance of Freshmen in Advanced Beginning Mathematics," Ohio Wesleyan University, 1959.

Study was designed to (1) help the mathematics department, through analysis of freshman performance test, to evaluate and improve the test, and (2) to explore possibilities of predicting student performance in advanced mathematics to aid in better placement of entering students.

Implications

The unfortunate thing about studies done under this title—and those reported here are no exception—is that success is measured in grades earned, or at least received, and in credits won or given. A second limitation of these studies is that there is no such thing as success in the mass. The success of one student may be great even if his achievement is modest in comparison with that of other students. The success of some students, which will appear to be satisfactory in these studies, may actually be a failure, because they have not made the achievement of which they are capable. More unfortunate is the fact that these tests do not measure a student's success in achieving a higher education. First, they do not measure his growth—and education is growth. Second, in many institutions the amount of higher education acquired cannot be measured by these units because, while the student may have 120 or more credits, only a part of them are in courses that are appropriate to higher education. Some of his credits are for courses in what is in fact secondary education. Neither do these tests measure a student's success in "learning to think," critically or creatively, or to think outside of the prejudices and orthodoxies he brought to college.

Finally, most institutions are not absolutely clear about what it is they propose to do. They cannot, accordingly, measure either their success or the success of their students in achieving their goals. Too many institutions are all things to all students, doing some things well but doing them less well than they might, because they feel they must do other things even if they do them poorly.

Conclusions

Modest as the effort must appear, there may be a livelier concern in engineering and the physical sciences for improving the thinking of students through problem-oriented approaches (Section I) than elsewhere in the curriculum. In an earlier review [7] of research on teaching practices irrespective of subject and types of institutions, 10 studies were identified. The blacklog of studies in the Clearinghouse is, of course, greater now and some "pump priming" was done to produce the 12 pieces on problem-oriented approaches in this paper, but the observation above still seems sound.

If to this observation about critical thinking one adds the scientist's obvious interest in creative thinking (see Appendix) it becomes apparent that the physical scientist and engineer is impressively motivated to improve his teaching with these outcomes in mind. The requests for this paper are another indication—none being forthcoming from other professional journals—of the substantial nature of the engineer's interest. In the area of utilization (Section II) engineers have been obviously very active.

In the area of curriculum it is the impression of Earl J. McGrath, of the Institute for Higher Education, Teachers College, Columbia University, that some of the most energetic and imaginative experimentation in liberal arts education (Section III) is being done in professional schools, including, of course, engineering. Finally, it would seem that engineering and the physical sciences almost have a corner on "prediction of success" studies (Section IV).

[7] "Effectiveness in Teaching," W. R. Hatch and Ann Bennet, *New Dimensions in Higher Education*, No. 2, Division of Higher Education, U. S. Office of Education.

It could be that the scientist, pure or applied, is somewhat more literal in his interpretation of what is meant by higher education than are his colleagues in other disciplines. Perhaps some of the subtleties and rationalizations that are used to defend the *status quo* are lost on him; not uniformly, of course, but in somewhat larger measure than is the case in other areas. It may be that the explanation for the engineer's and the scientist's experimentation with educational phenomena lies in their general experimental bent or in their scientific directness. Or these activities may be a reflection of the engineer's and the scientist's greater security. More secure because of their bargaining power and the somewhat greater esteem in which they are held by the general public, these faculties may be more disposed to welcome change.

Since competent faculties are those most disposed to experiment and since through experimentation better and more economical instructional practices are being discovered, it may well be that good faculties and programs will become progressively better and the poor ones relatively poorer.

The fact that the sciences and engineering are prospering at this moment, relatively speaking, may not then be due only to the national interest in science and national support of science but to the fact that the public at large senses that these faculties are alert, and are working energetically to improve their programs.

Since better and more economical ways of doing things are the best insurance an institution can take out against the certainties of the "bulge" it may be helpful if some of the attributes of these programs—some of the clauses in the contract—are identified. With such a list before it no institution need be under any illusions as to its state of readiness.

These aspects are:

1. Experimentation with or the early institution of sophisticated programs of *independent study*, including *honors programs;* not just any honors program but a modern one that reflects all that has been learned about such programs in the last decade.

2. A critical examination of the *impact of the college on its students.*

3. Provision for *advanced placement* and *early entrance.*

4. Curricular and administrative *flexibility.*

5. Institution of experiments or procedures looking toward improvement in *the quality of student learning and of teaching.* This will be reflected in the above but it is also manifested in the opportunities provided for student "inquiry"—for *problem-oriented instruction.*

6. Improving upon the quality of faculty learning and of its *research.* This will be reflected in part in the amount of basic research done, in contradistinction to applied research.

7. Provision for *curricular integration.* To the degree to which programs examine and exploit relationships, seek implications and recognize the primacy of ideas without minimizing fact—to this degree they are exploiting what is known about the theory of learning.

The defense of the unique American contribution to higher education, the education of the common man, too often seems to be a defense of the *status quo;* or even of the *status quo ante.* Such defenders of such institutions do not have to settle for a second rate education or, in effect, saddle their constituencies with a second-class citizenship. Any faculty that is content with *what is* and any administration that likes it this way is more vulnerable than perhaps it appreciates. Hard-handed and hardheaded supporters of higher education recognize that the only certain thing is change, that institutions which are not changing cannot be improving themselves.

Appendix

"The Development of a Criterion of Scientific Competence," Lindsey R. Harmon, *The Second (1957) University of Utah Research Conference on the Identification of Creative Scientific Talent,* 1958, pp. 82–97.

Report of National Science Foundation on establishing a criterion of scientific

competence for former AEC candidates, summarizing: questionnaire measuring criterion development; intercorrelations of criterion elements in physical science and biological science groups; validation of predictors against rating criterion for early, middle, and late Ph.D.'s.

"Some Variables Functioning in Productivity and Creativity," Calvin W. Taylor, *The Second* (1957) *University of Utah Research Conference on the Identification of Creative Scientific Talent*, 1958, pp. 3–19.

Research to understand and identify the fundamental nature of creative scientific talent so as to develop and encourage creativity and establish optimum environment for it. Report of four studies measuring variables functioning in productivity and creativity. Presentation of suggested lists of criteria on scientists and duties in scientific jobs.

"Variables Related to Creativity and Productivity Among Men in Two Research Laboratories," Donald W. Taylor, *The Second (1957) University of Utah Research Conference on the Identification of Creative Scientific Talent*, 1958, pp. 20–54.

Description of two naval laboratory studies exploring the relation of certain tests and other variables to creativity and productivity of men in research or development work. Presentation of correlations between checklists, descriptive ratings, tests, undergraduate grades; questions related to ratings of creativity and productivity.

Technical Institute in America

(*Continued from page 36*)

delimited by the official designation "vocational programs of less than college grade" and by the established policy of distributing such money and administering such programs through the vocational-trade education divisions of the public secondary school systems. Here is a specific task for ASEE.[7]

What of the Future?

It is but fitting and proper to close this discussion on the general theme of its opening: that both the national need and the career potential for the engineering technician is as broad and varied as the field of engineering itself. As with all developments in human affairs, the general realization and acceptance of this fact is evolving relatively slowly, with full measure of confusion, and against some opposition. However, the fact is established, and regardless of semantics the trend is growing—has even grown perceptibly in strength and direction since this Survey was initiated in 1956.

Conditions have changed drastically in the relative short history of engineering enterprise, and still are changing. Frontiers have moved, and still are moving. Manpower concepts, both social and professional, must keep pace. Both the concepts and the procedures relative to engineering science and related technologies as they affect the entire spectrum of technological manpower, both educationally and professionally, obviously must change accordingly.

In substantial measure the rate and quality of growth of the engineering technician in the technological manpower pattern will depend jointly upon the quality of technical institute education provided and perception and attitude of engineering educators and the engineering profession. Finally, may I urge again the desirability of maintaining the philosophical rather than the institutional approach to technical institute education —"The Technical Institute Idea in Higher Education."

[7] E. E. Booher, "Title VIII—Does It Fulfill Its Intent?", *Technical Education News*, April, 1959.

New Members of ASEE

New Active Institutional Member

ANTIOCH COLLEGE, Yellow Springs, Ohio; J. P. Dixon, Jr., *President;* W. B. Alexander, *Vice President and Dean;* R. A. Voelker, *Dean of Engineering* 1960

New Industrial Members

BABCOCK AND WILCOX COMPANY, 161 East 42nd Street, New York 17, N. Y. *Representative:* J. W. Andeen, Manager, Student Training 1960

BRIGGS AND STRATTON CORPORATION, 2711 North 13th Street, Milwaukee 1, Wis. *Representative:* H. S. Brown, Vice President, Engineering 1960

CARRIER CORPORATION, Carrier Parkway, Syracuse, N. Y. *Representative:* Wm. Flavin, Employment Manager 1960

DIAMOND ALKALI COMPANY, 300 Union Commerce Building, Cleveland 14, Ohio. *Representative:* G. H. Varney, Manager, Employee Recruiting Development 1960

GLOBE-UNION, INC., 900 East Keefe Avenue, Milwaukee, Wis. *Representative:* R. L. Wolff, Vice President, Engineering 1960

GRACE AND COMPANY, W. R., POLYMER CHEMICALS DIVISION, P. O. Box 3006, Istrouma Station, Baton Rouge 5, La. *Representative:* W. E. Maclean, Manager, Engineering and Maintenance 1960

KIMBERLY-CLARK CORPORATION, Neenah, Wis. *Representative:* C. G. R. Johnson, Chief Engineer 1960

VARIAN ASSOCIATES, 611 Hansen Way, Palo Alto, Calif. *Representative:* R. F. Mager, Senior Scientist 1960

VITRO WEAPONS SERVICES, General Delivery, Eglin Air Force Base, Fla. *Representative:* A. J. Erickson, General Manager 1960

WISCONSIN MOTOR CORPORATION, 1910 South 53rd Street, Milwaukee 46, Wis. *Representative:* F. B. Esty, Vice President 1960

New Affiliate Members

College of Technology, University of Houston, Houston 4, Tex.; A. Ray Sims, *Dean* . 1960

Erie County Technical Institute, 1685 Elmwood Avenue, Buffalo 7, N. Y.; L. E. Spring, *President;* Ernest Notar, *Dean* 1960

TECHNION-ISRAEL INSTITUTE OF TECHNOLOGY, P. O. Box 4910, Haifa, Israel, General Y. Dori, *President;* T. Gladstein, *Vice President in Charge of Research* 1960

New Individual Members

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METZGER, ROBERT S., Assistant Professor of Social Studies, North Carolina State College, Raleigh, N. C. 1960.

METZLER, DWIGHT F., Professor of Civil Engineering, University of Kansas, Lawrence, Kan. 1960.

MILANO, JOSEPH E., Manager, Research Education, International Business Machines Research Center, Yorktown Heights, N. Y. 1960.

MILLEDGE, RICHARD K., Instructor in Mechanical Engineering, Montana State College, Bozeman, Mont. 1960.

MILLER, ROBERT A., Professor of Civil Engineering, University of South Carolina, Columbia, S. C. 1960.

MINDER, THOMAS L., Librarian, College of Engineering, Pennsylvania State University, University Park, Pa. 1960.

MITCHELL, DAVID R., Professor of Mineral Engineering, The Pennsylvania State University, University Park, Pa. 1960.

MOHANRAO, GOVINDARAJU J., Research Fellow in Sanitary Engineering, California Institute of Technology, Pasadena, Calif. 1960.

MOHLER, RONALD R., Professor of Electrical Engineering, University of New Mexico, Los Alamos Graduate Center, Los Alamos, N. M. 1960.

MOLNAR, JOHN E., Special Lecturer in Engineering, The University of Texas, Austin 12, Tex. 1960.

MONAHAN, EDWARD J., Assistant Instructor in Civil Engineering, Newark College of Engineering, Newark, N. J. 1960.

MOORE, JOHN L., Instructor in Graphics, Purdue University, West Lafayette, Ind. 1960.

MOORE, THOMAS W., Instructor in Electrical Engineering, Drexel Institute of Technology, Philadelphia, Pa. 1960.

MORA, LUIS E., Instructor in Civil Engineering, College of Agriculture and Mechanic Arts, Mayaguez, Puerto Rico. 1960.

MORGAN, JAMES J., Instructor in Civil Engineering, University of Illinois, Urbana, Ill. 1960.

MORGENROTH, GEORGE W., Director of Vocational Education, Essex County Vocational and Technological Schools, Administrative Offices, 1060 Broad Street, Newark 2, N. J. 1960.

MORLEY, RICHARD E., Dean, Technical Education, Pensacola Junior College, Pensacola, Fla. 1960.

MORRIS, JAMES G., Assistant Professor of Metallurgy, University of Kentucky, Lexington, Ky. 1960.

MOULTON, EDWARD Q., Assistant Dean of Graduate School, Associate Professor of Civil Engineering, Ohio State University, 140 West 18th Avenue, Columbus 10, Ohio. 1960.

MOUZON, JAMES C., Associate Dean of Engineering, The University of Michigan, Ann Arbor, Mich. 1960.

MOWATT, WARREN P., Assistant Professor of Mechanical Engineering, Tennessee Polytechnic Institute, Cookeville, Tenn. 1960.
MULLEN, ANTHONY J., Chairman of Electrical Engineering, Villanova University, Villanova, Pa. 1960.
MUNGER, PAUL R., Instructor in Civil Engineering, Missouri School of Mines and Metallurgy, Rolla, Mont. 1960.
MUNSON, DARRELL E., Assistant Professor of Metallurgy, Washington State University, Pullman, Wash. 1960.
MURTHY, N. SURYANARAYANA, c/o N. Chandrasekhara Rao, Gujarathipeta, Srikakulam (P.O & Dt.), Andhra Pradesh, India. 1960.
MUSS, DAVID L., Assistant Professor of Civil Engineering, City College of New York, New York 31, N. Y. 1960.
MYERS, EDWARD J., Assistant Professor of Metallurgy and Mechanics, Institute of Technology, Air University, Wright-Patterson Air Force Base, Ohio. 1960.

NAHI, NASSER E., Assistant Professor of Electrical Engineering, University of Southern California, Los Angeles, Calif. 1960.
NASH, THOMAS H., JR., Instructor in Engineering, Duke University, Durham, N. C. 1960.
NEOU, CHING-YUAN, Professor of Mechanical Engineering, University of Bridgeport, Bridgeport 4, Conn. 1960.
NEWMAN, DONALD G., Assistant Professor of General Engineering, San Jose State College, San Jose 14, Calif. 1960.
NEWMAN, ROBERT E., 2415 Maplewood Avenue, Toledo 6, Ohio. 1960.
NICHOLS, GROVER T., Associate Professor of Electrical Engineering, Auburn University, Auburn, Ala. 1960.
NONEAKER, DANIEL O., Instructor in Electrical Engineering, Auburn University, Auburn, Ala. 1960.
NORRIS, MAX H., Assistant Professor of Engineering Graphics, Purdue University, Lafayette, Ind. 1960.
NORTON, JOHN H., Industrial Market Research Analyst, E. I. du Pont de Nemours & Company, Inc., Wilmington 98, Del. 1960.
NORWOOD, HARRY P., Instructor in Mathematics and Engineering, Amarillo College, Amarillo, Tex. 1960.
NOWAK, RICHARD T., Assistant Professor of Physics, University of Toledo, Toledo, Ohio. 1960.
NOYES, THEODORE A., Assistant Professor of Mechanical Engineering, Texas Agricultural and Mechanical College, College Station, Tex. 1960.

O'BRIEN, EDMUND R., Director of Training Division, United States Army Engineering School, Fort Belvoir, Va. 1960.
O'CONNELL, ELIAS M., Instructor in Mechanical Engineering, University of New Hampshire, Durham, N. H. 1960.
O'CONNOR, C. LEONARD, Associate Professor of Physics, Manhattan College, New York 71, N. Y. 1960.
OKUN, DANIEL A., Professor of Sanitary Engineering, University of North Carolina, Chapel Hill, N. C. 1960.
ÖLÇER, NURETTIN Y., Graduate Fellow in Mechanical Engineering, Northwestern Technological Institute, Northwestern University, Evanston, Ill. 1960.
OLÉN, CARL L., Assistant Professor of Electrical Engineering, University of Arkansas, Fayetteville, Ark. 1960.
ORR, ARLYN A., Assistant Professor of Architectural Engineering, Oklahoma State University, Stillwater, Okla. 1960.
OSWALT, JESSE H., Instructor in Mechanical Engineering, Mississippi State University, State College, Miss. 1960.
OVERMYER, ELLIS J., Research Engineer of Mechanical Equipment, Boeing Airplane Company, Renton, Wash. 1960.
OWEN, WILLIAM E., Professor of Electrical Engineering, Louisiana State University, Baton Rouge, La. 1960.

PALLADINO, NUNZIO J., Professor and Head of Nuclear Engineering, The Pennsylvania State University, University Park, Pa. 1960.
PARCHER, JAMES V., Associate Professor of Civil Engineering, Oklahoma State University, Stillwater, Okla. 1960.
PARMELEE, GEORGE V., Staff Specialist, Arabian Oil Company, Dhahran, Saudi, Arabia. 1960.
PARODI, ANTONIO M., Instructor in Civil Engineering, College of Agriculture and Mechanic Arts, Mayaguez, Puerto Rico. 1960.
PARR, ROBERT E., Instructor in Engineering, Northrop Institute of Technology, Inglewood, Calif. 1960.
PASCUA, DOMINADOR G., Associate Professor, University of Puerto Rico, Mayaguez, Puerto Rico. 1960.
PATRICK, LAWRENCE M., Associate Professor of Engineering Mechanics, Wayne State University, Detroit, Mich. 1960.
PAUL, PURTON, Assistant Professor of Engineering, Brown University, Providence 12, R. I. 1960.
PAVELKO, FRANK D., Professional and Technical Training Supervisor, Lockheed Missiles and Space Division, Lockheed Aircraft Corporation, Sunnyvale, Calif. 1960.
PEDERSEN, GEORGE L., Associate Professor of Engineering and Graphics, Grove City College, Grove City, Pa. 1960.
PENNINGTON, THOMAS, Senior Supervisor of Engineering, Production Department, Humble Oil & Refining Company, Houston 1, Tex. 1960.
PETERSON, RICHARD C., Education Consultant, Engineering Personnel Service, General Electric Company, Cincinnati 15, Ohio. 1960.
PEYRONNIN, CHESTER A., JR., Associate Professor of Mechanical Engineering, Tulane University, New Orleans 18, La. 1960.
PHILLIPS, GOVER T., Coordinator of Cooperative Education, Personnel Department, Chance Vought Aircraft, Inc., P. O. Box 5907, Dallas 22, Tex. 1960.
PLATE, ARTHUR C., Instructor in Engineering Graphics, University of Cincinnati, Cincinnati 21, Ohio. 1960.
POLAK, ARNOLD, Instructor in Mathematics and Mechanics, University of Cincinnati, Cincinnati 20, Ohio. 1960.
POTEET, ROBERT E., Professor of Engineering Mechanics, Northrop Institute of Technology, Inglewood, Calif. 1960.
POTTER, MERLE C., Instructor in Engineering Mechanics, Michigan College of Mining and Technology, Houghton, Mich. 1960.
POWELL, FRANCIS C., Associate Head of Electrical Engineering, Drexel Institute of Technology, Philadelphia 4, Pa. 1960.
PRINGLE, HOMER G., JR., Instructor in Mechanics, Air Force Institute of Technology, Wright-Patterson Air Force Base, Dayton, Ohio. 1960.
PRITCHETT, HAROLD D., Instructor in Civil Engineering, Oregon State College, Corvallis, Ore. 1960.
PYRON, HOWARD D., Instructor in Mathematics, Missouri School of Mines and Metallurgy, Rolla, Mo. 1960.

RAFERT, WALTER E., Assistant Professor of Armament Engineering, United States Military Academy, West Point, N. Y. 1960.
RAINWATER, JEWEL G., Instructor in Chemical Engineering, University of Arkansas, Fayetteville, Ark. 1960.
RALHAN, NARINDER K., Sectional Officer M.P. P.W.D. (B & R), Madhyd Pradesh P. W. D. (Buildings & Roads Branch), Rewa (M.P.), India. 1960.

RAMM, GEORGE G., Assistant Professor of Electrical Engineering, University of South Carolina, Columbia, S. C. 1960.

REDMON, JOHN K., Assistant Professor of Electrical Engineering, Newark College of Engineering, Newark 2, N. J. 1960.

REID, TOM P., Instructor in Industrial Engineering, Clemson College, Clemson, S. C. 1960.

REYNOLDS, JIMMIE L., Instructor in Mechanical Engineering, Tri-State College, Angola, Ind. 1960.

REYNOLDS, MARGUERITE R., President, Rhode Island Radio and Electronics School, 45 Mathewson Street, Providence 3, R. I. 1960.

RICHARD, CHARLES W., JR., Instructor in Mathematics, Air Force Institute of Technology, Air University, Wright-Patterson Air Force Base, Ohio. 1960.

RICHMAN, PETER D., Research Assistant in Industrial Engineering, Stevens Institute of Technology, Hoboken, N. J. 1960.

RIMBEY, DONALD H., Instructor in General Engineering, University of Illinois, Urbana, Ill. 1960.

RIVERA, ALEJANDRO, Assistant Professor of Electrical Engineering, University of Puerto Rico, College Station, Mayaguez, Puerto Rico. 1960.

RIVERIN, PAUL E., Chairman of Mining and Ore Dressing, Ecole Polytechnique, Montreal 26, Quebec, Canada. 1960.

ROBERTSON, WILLIAM D., Professor and Chairman of the Department, Yale University, New Haven, Conn. 1960.

ROBINSON, DONALD C., Associate Professor of Electrical Engineering, West Virginia Institute of Technology, Montgomery, W. Va. 1960.

ROBINSON, GILBERT C., Professor and Head of Ceramic Engineering, Clemson College, Clemson, S. C. 1960.

RODRIGUEZ, JUAN F., Instructor in General Engineering, University of Puerto Rico, Mayaguez, Puerto Rico. 1960.

ROESCH, WALTER A., Librarian, University of Dayton, Dayton 9, Ohio. 1960.

ROGERS, BRUCE G., Instructor in Theoretical and Applied Mechanics, University of Illinois, Urbana, Ill. 1960.

ROLL, WILLIAM H., Assistant Professor of Mining Engineering, University of Kentucky, Lexington, Ky. 1960.

ROLLER, HARRY E., Department of Engineering, Skagit Valley College, Mount Vernon, Wash. 1960.

ROMMEL, ALEXANDER R., Head of Personnel Placement and Services, Employee Relations Department, Humble Oil and Refining Company of Delaware, Houston, Tex. 1960.

ROOT, JAMES G., Instructor in Industrial Engineering, Ohio State University, Columbus, Ohio. 1960.

ROSE, LEWIS W., Educational Specialist, United States Army Engineer School, Fort Belvoir, Va. 1960.

ROSENBLATT, ARTHUR B., Technical Editor, Engineering Department, Capitol Radio Engineering Institute, Washington 10, D. C. 1960.

ROSENKRANZ, LOUIS J., President, National Technical Schools, Los Angeles 37, Calif. 1960.

RUSSELL, GEORGE R., Assistant Professor of Civil Engineering, University of Idaho, Moscow, Idaho. 1960.

RUSSELL, MARK L., Co-operative Coordinator, Civilian Personnel Department, Army Ballistic Missile Agency, Redstone Arsenal, Ala. 1960.

SAADEH, FUAD T., Assistant Professor of Mechanical Engineering, The University of Texas, Austin 12, Tex. 1960.

SACHS, HERBERT K., Associate Professor of Engineering Mechanics, Wayne State University, Detroit, Mich. 1960.

SAGE, JOSEPH D., Assistant Professor of Civil Engineering, Worcester Polytechnic Institute, Worcester, Mass. 1960.

SALIS, ANDREW E., Head and Professor of Electrical Engineering, Arlington State College, Arlington, Tex. 1960.

SALT, DALE L., Assistant Professor of Chemical Engineering, University of Utah, Salt Lake City 12, Utah. 1960.

SAMPSON, EDWARD, JR., Assistant Professor of Civil Engineering, University of Colorado, Boulder, Colo. 1960.

SANDERS, FRED, Head of Mechanical Technology, Broome Technical Community College, Binghamton, N. Y. 1960.

SANTIAGO-VAZQUEZ, ANTONIO, Instructor in General Engineering, University of Puerto Rico, Mayaguez, Puerto Rico. 1960.

SAXE, HARRY C., Professor and Head of Civil Engineering, University of Notre Dame, Notre Dame, Ind. 1960.

SCHILLER, ROGER W., Instructor in Mechanical Engineering, The Pennsylvania State University, University Park, Pa. 1960.

SCHLIMMEYER, WILBERT H., Assistant Professor of Civil Engineering, Rutgers University, New Brunswick, N. J. 1960.

SCHURE, ALEXANDER, President, New York Institute of Technology, New York 23, N. Y. 1960.

SCHUTZ, FREDERICK W., JR., Professor of Civil Engineering, Georgia Institute of Technology, Atlanta 13, Ga. 1960.

SCOUTEN, DONALD C., Instructor in Electrical Engineering, Oklahoma State University, Stillwater, Okla. 1960.

SCRIVEN, L. E., Assistant Professor of Chemical Engineering, University of Minnesota, Minneapolis 14, Minn. 1960.

SEES, J. EDWIN, Associate Professor of Electrical Engineering, University of South Carolina, Columbia, S. C. 1960.

SEIDMAN, ARTHUR H., Lecturer in Electrical Engineering, City College of New York, New York 31, N. Y. 1960.

SHAND, JULIAN B., Associate Professor of Civil Engineering, University of South Carolina, Columbia, S. C. 1960.

SHANKLIN, MILTON D., Associate Professor of Agricultural Engineering, University of Missouri, Columbia, Mo. 1960.

SHAPIRO, MAURICE A., Associate Professor of Sanitary Engineering, University of Pittsburgh, Pittsburgh 13, Pa. 1960.

SHAW, JAMES F., Instructor in Machine Processes, Wentworth Institute, Boston, Mass. 1960.

SHAW, RICHARD P., Assistant Professor of Engineering Science, Pratt Institute, Brooklyn 5, N. Y. 1960.

SHELSTAD, KENNETH A., Assistant Professor of Chemical Engineering, McGill University, Montreal 2, Quebec, Canada. 1960.

SHOVE, GENE C., Associate Professor of Agricultural Engineering, University of Illinois, Urbana, Ill. 1960.

SHREEVE, CHARLES A., JR., Head of Mechanical Engineering, University of Maryland, College Park, Md. 1960.

SHULMAN, YECHIEL, Assistant Professor of Mechanical Engineering, Northwestern University, Evanston, Ill. 1960.

SIEMIENCOW, GEORGE, Instructor in Chemistry, Lafayette College, Easton, Pa. 1960.

SIGUARDSON, WILLIAM A., Assistant Professor of Engineering Drawing, University of North Dakota, Grand Forks, N. D. 1960.

SILLCOX, LEWIS K., Director, Office of Transportation, State of New York, 3002 State Office Building, P. O. Box 7071, Albany 1, N. Y. 1960.

SINNOTT, MAURICE J., Professor of Chemical and Metallurgical Engineering, University of Michigan, Ann Arbor, Mich. 1960.

SISKIND, CHARLES S., Associate Professor of Electrical Engineering, Purdue University, Lafayette, Ind. 1960.

SITZWOHL, JOSEPH F., Associate Professor of Electrical Engineering, Milwaukee School of Engineering, Milwaukee, Wis. 1960.

SLIGER, ELLIOTT T., Director of Educational Department, Combustion Engineering, Inc., Chattanooga, Tenn. 1960.

SLOBOD, ROBERT L., Head and Professor of Petroleum and Natural Gas, The Pennsylvania State University, University Park, Pa. 1960.

SMALTZ, JACOB J., Professor of Industrial Engineering, Kansas State University, Manhattan, Kan. 1960.

SMELSER, REX H., Director, Sowela Vocational-Technical School, 600 Kirkman Street, Lake Charles, La. 1960.

SMITH, JAMES G., Assistant Professor of Electrical Engineering, Missouri School of Mines and Metallurgy, Rolla, Mo. 1960.

SMITH, JAMES P., Instructor in Mechanical Engineering, Auburn University, Auburn, Ala. 1960.

SMITH, JOSEPH H., JR., Assistant Head of Electrical Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. 1960.

SMITH, RAYMOND L., Head of Metallurgical Engineering, Michigan College of Mining and Technology, Houghton, Mich. 1960.

SMITH, ROBERT B., Instructor in Civil Engineering, University of Mississippi, University, Miss. 1960.

SMITHMEYER, FREDERICK C., Instructor in Mining and Metallurgical Engineering, The University of Kansas, Lawrence, Kan. 1960.

SNEDEKER, JOHN T., Instructor in Electrical Engineering, Milwaukee School of Engineering, Milwaukee 1, Wis. 1960.

SORENSEN, SVEND E., Assistant Professor of Mechanical Engineering, Ohio University, Athens, Ohio. 1960.

SOTO, JOAQUIN P., Professor of Industrial Engineering, University of Puerto Rico, Mayaguez, Puerto Rico. 1960.

SPRADLING, JAMES C., Associate Professor of Mechanics, Wisconsin State College and Institute of Technology, Platteville, Wis. 1960.

SPRAGUE, CARLTON S., Professor of Electrical Engineering, Purdue University, Lafayette, Ind. 1960.

STERLING, THOMAS E., Assistant Professor of General Engineering, Pennsylvania State University, University Park, Pa. 1960.

STEWART, EDWIN, JR., Coordinator, Industrial Coordination, Drexel Institute of Technology, Philadelphia, Pa. 1960

STEWART, ORVILLE W., Associate Professor of Mechanical Engineering, University of Kentucky, Lexington, Ky. 1960.

STOELK, HERMAN W., Instructor in Engineering Technology, Purdue University, Lafayette, Ind. 1960.

STONE, IRA C., JR., Supervisor, Polaris Missile System Training, Lockheed Missiles and Space Division, Lockheed Aircraft Corporation, Sunnyvale, Calif. 1960.

STORMS, RAYMOND E., Assistant Professor of Petroleum and Geological Engineering, Louisiana Polytechnic Institute, Ruston, La. 1960.

STRADLING, LESTER J., JR., Associate Professor of Mechanical Engineering, Drexel Institute of Technology, Philadelphia 11, Pa. 1960.

STRAWN, OLIVER P., JR., Assistant Professor of Mechanical Engineering, Virginia Polytechnic Institute, Blacksburg, Va. 1960.

STRUTYNSKI, JOZEF S., Senior Instructor of Associate Engineering Division, Oretech Branch, Oregon Technical Institute, Klamath Falls, Ore. 1960.

SU, KENDALL L., Associate Professor of Electrical Engineering, Georgia Institute of Technology, Atlanta 13, Ga. 1960.

SUMMER, HENRY M., Associate Professor of Electrical Engineering, Auburn University, Auburn, Ala. 1960.

SWAGER, WARREN M., Associate Professor of Industrial Engineering, University of Buffalo, 14, N. Y. 1960.

SWEARINGEN, THOMAS B., Instructor in Mechanical Engineering, Washington State University, Pullman, Wash. 1960.

SZE, TSUNG W., Fessenden Professor of Electrical Engineering, University of Pittsburgh, Pittsburgh 13, Pa. 1960.

SZILARD, RUDOLPH, Associate Professor of Civil Engineering, Colorado State University, Fort Collins, Colo. 1960.

TAYLOR, JOHN, Professor of Electrical Engineering, University of South Carolina, Columbia, S. C. 1960.

TEWFIK, MOHAMED M., Associate Professor of Civil Engineering, Auburn University, Auburn, Ala. 1960.

THELANDER, THEODORE A., Associate Professor of History, Government and Philosophy, Purdue University, Indianapolis Branch, Indianapolis, Ind. 1960.

THOMAS, JOHN P., Assistant Professor of Mechanical Engineering, Institute of Technology, Air University, Wright-Patterson Air Force Base, Ohio. 1960.

THOMPSON, HANNIS W., JR., Instructor in Electrical Engineering, North Carolina State College, Raleigh, N. C. 1960.

THOMS, ROBERT L., Instructor in Theoretical and Applied Mechanics, University of Illinois, Urbana, Ill. 1960.

TINKER, WARREN H., Head of Electrical Engineering, Prairie View Agricultural and Mechanical College, Prairie View, Tex. 1960.

TITTLE, CHARLES W., Professor of Nuclear Engineering, Southern Methodist University, Dallas, Tex. 1960.

TOEBES, GERRIT H., Assistant Professor of Civil Engineering, Purdue University, Lafayette, Ind. 1960.

TONG, LONG SUN, Supervisory Engineer, Thermal and Hydraulic Design, Atomic Power Department, Westinghouse Electric Corporation; Lecturer in Mechanical Engineering, University of Pittsburgh, Pittsburgh, Pa. 1960.

TORO-GOYCO, EDWIN, Assistant Professor of General Engineering, College of Agriculture and Mechanic Arts, Mayaguez, Puerto Rico. 1960.

TORPEY, WILLIAM G., Consultant, Executive Office of the President of the United States, Office of Civil and Defense Mobilization, Washington, D. C. 1960.

TRASK, IRWIN A., Department Head, Highway Technology, Vermont Agricultural and Technical Institute, Randolph Ctr., Vt. 1960.

TREGO, JOHN W., Training Specialist, Education: Personnel Department, Hughes Aircraft Company, Fullerton, Calif. 1960.

TURMAN, GEORGE B., Instructor in Industrial Education and Mechanical Engineering, Tennessee Arts and Industrial State University, Nashville 8, Tenn. 1960.

TYSON, HERBERT I., Instructor in Engineering, Extension Division, University of the State of New York, Rockland Community College, Suffern, N. Y. 1960.

UHL, ARTHUR E., Institute of Gas Technology, Illinois Institute of Technology, Chicago 16, Ill. 1960.

ULM, LESTER, JR., General Engineer, Tampa Electric Company, P. O. Box 111, Tampa 1, Fla. 1960.

UPPVALL, CHARLES P., Director of Admissions, Wentworth Institute, Boston 15, Mass. 1960.

VACHON, REGINALD I., Research Assistant in Mechanical Engineering, Auburn University, Auburn, Ala. 1960.

VALENTIN, AUSBERTO G., Professor of Industrial Engineering, University of Puerto Rico, Mayaguez, Puerto Rico. 1960.

VAN DER REYDEN, DIRK, Associate Professor of Industrial Engineering, Washington University, St. Louis 30, Mo. 1960.

VANNICE, WILLIAM J., Area Employment Supervisor Executive, Southwestern Bell Telephone Company, St. Louis, Mo. 1960.

VARADARAJAN, RASIPUR N., Assistant Professor of Mechanical Engineering, A. C. College

of Engineering and Technology, Karaikudi 3, Madras State, India. 1960.

VEATCH, RALPH W., Professor and Head of Mathematics, University of Tulsa, Tulsa, Okla. 1960.

VECKARELLI, CLARENCE A., Associate Professor of Engineering Graphics, University of Miami, Coral Gables, Fla. 1960.

VENK, ERNEST A., Assistant Dean of Technical Education, Henry Ford Community College, Dearborn, Mich.

VIVAS-ROSALY, EDUARDO N., Associate Professor of General Engineering, University of Puerto Rico, Mayaguez, Puerto Rico. 1960.

WADLEIGH, KENNETH R., Associate Professor of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1960.

WAGNER, DONALD E., Assistant Professor of Engineering Drawing, Bucknell University, Lewisburg, Pa. 1960.

WAGNER, ROBERT E., Associate Professor of Chemical Engineering, Worcester Polytechnic Institute, Worcester 9, Mass. 1960.

WAHL, EMIL D., Instructor in Chemical Engineering, University of North Dakota, Grand Forks, N. D. 1960.

WAHL, MILTON H., Director, Savannah River Laboratory, E. I. duPont de Nemours and Company, Aiken, S. C. 1960.

WAINERDI, RICHARD E., Assistant to the Dean and Associate Professor of Petroleum Engineering, Texas Agricultural and Mechanical College, College Station, Tex. 1960.

WALKER, SCOTT W., Dean of Petroleum Sciences and Engineering, The University of Tulsa, Tulsa, Okla. 1960.

WALLACK, PAUL M., Assistant Professor of Industrial Engineering, Arizona State University, Tempe, Ariz. 1960.

WALLER, EDWIN J., Associate Professor of Civil Engineering, Oklahoma State University, Stillwater, Okla. 1960.

WALTERS, ERNEST G., Superintendent, Training Engineering, Western Electric Company, New York 17, N. Y. 1960.

WARD, JOHN R., Assistant Professor of Engineering, Brown University, Providence 12, R. I. 1960.

WARD, LOUIS R., Professor and Head of Languages and Social Sciences, South Dakota School of Mines and Technology, Rapid City, S. D. 1960.

WASHINGTON, DONALD R., Assistant Professor of Civil Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. 1960.

WAUGH, JOHN D., Instructor in Civil Engineering, University of South Carolina, Columbia, S. C. 1960.

WEBB, PHILIP E., Instructor in Engineering Graphics, University of Michigan, Ann Arbor, Mich. 1960.

WEED, MERWIN L., Instructor in Civil Engineering, University of Pittsburgh, Pittsburgh 13, Pa. 1960.

WEEKS, WALTER L., Professor of Electrical Engineering, New Mexico State University, University Park, N. M. 1960.

WEESE, JOHN A., Instructor in Mechanics, United States Air Force Academy, Colo. 1960.

WEINER, PETER D., Assistant Professor of Mechanical Engineering, Texas Agricultural and Mechanical College, College Station, Tex. 1960.

WELLS, WILLIAM G., Instructor in Mechanical Engineering, Mississippi State University, State College, Miss. 1960.

WEYNAND, EDMUND E., Professor of Mechanical Engineering, Southern Methodist University, Dallas, Tex. 1960.

WHETSTONE, WILLIAM D., Instructor in Mechanical Engineering, Auburn University, Auburn, Ala. 1960.

WHICHER, WILLIAM C., Instructor in Aeronautical Engineering, Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio. 1960.

WHINNERY, JOHN R., Dean of Engineering, University of California, Berkeley 4, Calif. 1960.

WHIPPLE, ROYSON N., President, State University of New York Agricultural and Technical Institute, Morrisville, N. Y. 1960.

WHITE, EDWARD J., Instructor in Electrical Engineering, University of Virginia, Charlottesville, Va. 1960.

WHITESCARVER, CARRELL D., Instructor in Electrical Engineering, New Mexico State University, Park, N. M. 1960.

WHITMAN, WALTER G., Head of Chemical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 1960.

WHITWER, DONALD H., Senior Instructor in Allied Arts and Sciences, Oretech Branch, Oregon Technical Institute, Klamath Falls, Ore. 1960.

WIELAND, DENTON R., Assistant Professor of Petroleum Engineering, University of Tulsa, Tulsa, Okla. 1960.

WILLENBROCK, F. KARL, Associate Director of Laboratories, Harvard University, Cambridge 38, Mass. 1960.

WILLIAMS, DAVID T., Professor of Aeronautical Engineering, University of Florida, Gainesville, Fla. 1960.

WILLIAMS, RICHARD B., Instructor in Engineering Graphics, University of Cincinnati, Cincinnati 21, Ohio. 1960.

WILSON, CHARLES J., Instructor in Mechanical Engineering, Fenn College, Cleveland, Ohio. 1960.

WILSON, THOMAS G., Associate Professor of Electrical Engineering, Duke University, Durham, N. C. 1960.

WISNER, HOWARD L., Associate Professor of Electrical Engineering, Purdue University Extension, 902 North Meridian Street, Indianapolis, Ind. 1960.

WOODHAM, JOHN F., Associate Professor of Chemical Engineering, Southwestern Louisiana Institute, Lafayette, La. 1960.

WORD, ORVILLE C., JR., Special Instructor in Drawing, University of Texas, Austin, Tex. 1960.

WRIGHT, J. RICHARD, Instructor in Mechanical Engineering, Tennessee Polytechnic Institute, Cookeville, Tenn. 1960.

WYLIE, EVAN B., Assistant Professor of Civil Engineering, University of Denver, Denver 10, Colo. 1960.

YALCIN, METE, Instructor in Civil Engineering, Ohio Northern University, Ada, Ohio. 1960.

YOUNG, FRANCIS M., Instructor in Mechanics and Electricity, Montana School of Mines, Butte, Mont. 1960.

YOUNKIN, LARRY M., Instructor in Engineering, Geneva College, Beaver Falls, Pa. 1960.

ZAGEL, S. J., President, Compco Corporation, 1800 North Spaulding, Chicago 47, Ill. 1960.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny		April, 1961	E. R. Schatz, Carnegie Institute of Technology
Illinois-Indiana	Ill. Inst. of Tech.	May 13, 1961	Peter Chiarulli, Ill. Inst. of Tech.
Kansas-Nebraska	Univ. of Wichita	Oct. 21–22, 1960	H. L. Kipp, Univ. of Kansas
Michigan	Michigan State U.	April 22, 1961	L. L. Otto, Mich. State Univ.
Middle Atlantic	Drexel Inst. of Tech.	Dec. 3, 1960	F. L. Singer, New York Univ.
Missouri-Arkansas	Saint Louis Univ.	April 8, 1961	V. T. Allen, Saint Louis Univ.
National Capital Area		Oct., 1960	Geo. H. Hickox, Ft. Belvoir, Va.
New England	Wentworth Inst. Boston, Mass.	Oct. 15, 1960	E. F. Littleton, Tufts Univ.
North Midwest	Marquette Univ.	Oct., 14–15, 1960	R. J. Kipp, Marquette Univ.
Ohio	Ohio State Univ.	April, 1961	R. S. Green, Ohio State Univ.
Pacific Northwest	Univ. of Washington	May, 1961	H. P. Mittet, Univ. of Washington
Pacific Southwest	Stanford University	Dec. 28–29, 1960	R. J. Parden, U. of Santa Clara
Rocky Mountain	University of Wyoming	Apr. 28–29, 1961	A. J. McGaw, Univ. of Wyoming
Southeastern	Univ of Mississippi	April 20–21, 1961	W. J. Seeley, Duke Univ.
Southwest	Univ. of Tulsa	Apr. 7–8, 1961	G. B. Tims, Jr., Lamar State College
Upper N. Y.-Ontario	University of Buffalo	Oct. 21–22, 1960	C. M. Fogel, Univ. of Buffalo

Mid-Winter Meetings–1961

Cooperative Education — Jan. — University of Detroit

Information: D. C. Hunt, Director of Coordination and Placement, University of Detroit, Detroit, Mich.

Engineering Graphics — Jan. 19–21 — University of Wichita

Information: A. C. Risser, Head, Engineering Drawing, University of Wichita, Wichita, Kansas

College-Industry Conference — Feb. 2–3 — University of Cincinnati

Information: C. Wandmacher, Assoc. Dean of Engineering, University of Cincinnati, Cincinnati, Ohio

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PROFESSORSHIP DEPARTMENT OF Earth, Space & Graphic Sciences, U. S. Military Academy, September 1961. Dept. teaches Engineering Drawing, Descriptive Geometry, Graphical Mathematics, Surveying, Physical and World Geography, and Astronomy. Teaching experience and related degrees desirable, not essential. Address inquiries, applications and qualifications promptly to: Superintendent, USMA, West Point, New York.

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MECHANICAL ENGINEER–SPECialist in Machine Design, needed for two year assignment with University of Kentucky-International Cooperation Administration Contract Team at the Bandung Institute of Technology, Java, Indonesia. Ph.D. with extensive experience preferred, but M.A. will be considered. Salary and rank open. Send biographical data with small picture to Coordinator of ICA Projects, Kentucky Research Foundation, University Station, Lexington, Kentucky.

HIGHWAY MATERIALS RESEARCH engineer to direct expanding program. Salary and rank will depend on qualifications. Advanced degree and professional registration desirable. Write to G. A. Riedesel, Division of Industrial Research, Washington State University, Pullman, Washington.

PH.D. IN MECHANICAL ENGINEERing wanted at accredited Engineering School to work in graduate program. Research and consultation permitted. Salary open dependent upon ability and experience. Write to 51-2, JOURNAL OF ENGINEERING EDUCATION, University of Illinois, Urbana, Illinois.

ELECTRICAL ENGINEERING–Ph.D.'s or equivalent needed to implement a doctoral program in engineering. Electrical fields of interest are computers, advanced circuit theory, advanced communications, control engineering, and solid-state. Liberal employment policies and fringe benefits, excellent opportunities for research and graduate teaching, tremendous potential for development in a highly industrialized area. Write Frederic P. Fischer, Chairman, Electrical Engineering Department, University of Buffalo, Buffalo 14, New York.

ASSISTANT PROFESSOR OR INstructor preferably with an interest in gas dynamics to teach undergraduate courses in fluid mechanics and applied mechanics. Applicant will be expected to set up a research program in his field of interest and to contribute to the post-graduate instruction program. Good academic and research background desired, preferably with a Ph.D. Appointment September or later depending upon availability. Write Head, Department of Mechanical Engineering, University of British Columbia, Vancouver 8, Canada.

PROFESSORSHIP IN DEPARTMENT of Electricity, U. S. Military Academy. Interest and experience in undergraduate teaching of electrical science and nuclear physics. M.S. degree at least required, military experience and youth desirable. Rank of lieutenant colonel. Address applications to Colonel E. R. Heiberg, Professor of Mechanics, U.S.M.A., West Point, N. Y., preferably prior to 15 November.

ASSISTANT PROFESSOR FOR SEmester starting Feb. 1961 in field of civil or electrical engineering to teach undergraduate program. Write to Chairman, Engr. Dept., Fresno State College, Fresno 26, Calif.

EXCELLENT OPPORTUNITIES available at San Jose State College in electrical and mechanical engineering beginning either February or September 1961. Appointments at Associate Professor level to qualified Ph.D.'s. Located in San Francisco Bay Area, center of expanding research, development, and manufacturing activities. Contact Norman O. Gunderson, Dean of Engineering, San Jose State College, San Jose 14, California.

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OPPORTUNITIES AT OHIO COLlege of Applied Science, Cincinnati, Ohio, for qualified men in Electrical Engineering Technology and Civil Engineering Technology. Preference given to a Professioal Engineer who would like to teach application. These jobs are challenging with excellent future possibilities. Address inquiries to Dean Edward L. Fleckenstein, Ohio College of Applied Science, 1104 Walnut Street, Cincinnati 10, Ohio.

MANAGEMENT ENGINEERING teaching and research positions at rank and salary appropriate with education and professional background. Ph.D. required. Have active major research projects, and consultation is encouraged. Contact D. W. Karger, Professor and Head, Department of Management Engineering, Rensselaer Polytechnic Institute, Troy, N. Y.

KINEMATICS SPECIALIST WITH analytical and design interests, for research and teaching, including mechanisms and advanced kinematics, assistant or associate professorship, start February or September 1961. Write Dept. of Machine Design, Upson Hall, Cornell University, Ithaca, N. Y.

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